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February 2010

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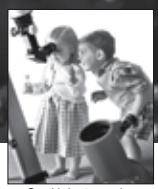

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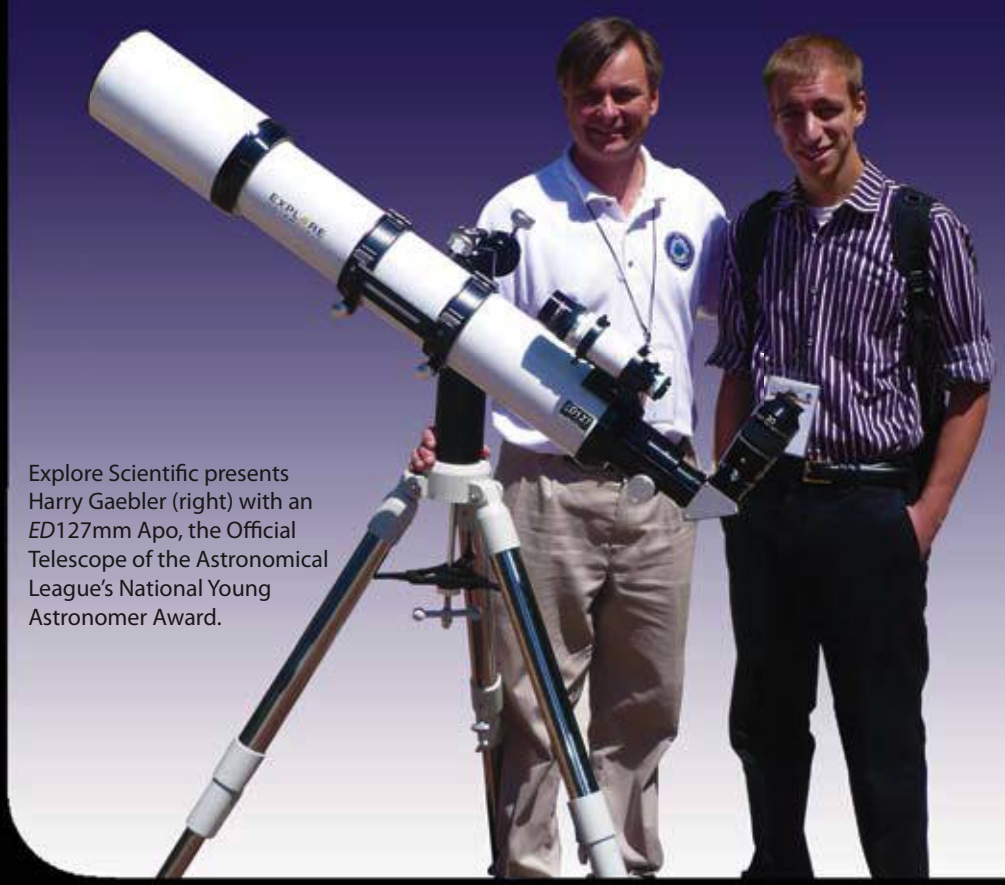

Explore Scientific presents Harry Gaebler (right) with an *ED*127mm Apo, the Official Telescope of the Astronomical League's National Young Astronomer Award.

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Astronomy
The world's best-selling astronomy magazine
February 2010

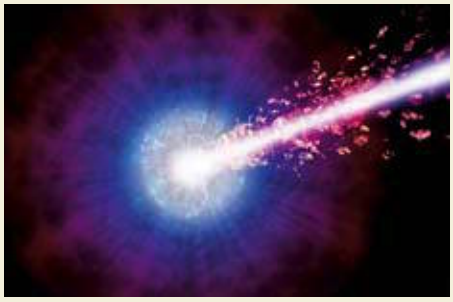
CENTER PULLOUT

Path of the planets and StarDome.

Cover: NASA/ESA/Hubble SM4 ERO Team

ON THE COVER
The past year saw many big stories about cosmology, our solar system, and exoplanets. *Astronomy* editors have narrowed down the top 10.

FEATURES



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Astronomy (ISSN 0091-6358, USPS 531-350) is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Periodicals postage paid at Waukesha, WI, and additional offices. POSTMASTER: Send address changes to *Astronomy*, 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Canada Publication Mail Agreement # 40010760.

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Astronomy magazine is on a mission

by David J. Eicher

Here at Kalmbach Publishing Co., employees spend time each month analyzing how we can better serve our customers. The magazine's mission statement reads: "*Astronomy* informs, entertains, and inspires people who are interested in the science and hobby of astronomy. We accomplish this by providing clear and accurate coverage of astronomy news and research, along with guidance for observing and imaging. *Astronomy* is the leader in its field, promoting the hobby, building enthusiasm for the science, and helping astronomy grow by serving our customers."

Recently, we asked some of our customers for feedback about why they read *Astronomy*. "I read *Astronomy* because it offers clear writing, vivid images, and imaginative reporting on all aspects of the field," says Adam Frank, astronomer at the University of Rochester.

"We read *Astronomy* because it covers not only the technical aspects of the science, but also the people who bring new knowledge and discoveries to light," say Imelda Joson and Edwin Aguirre, well-known Massachusetts amateur astronomers, writers, and photographers.

"I read *Astronomy* because the content is varied and interesting, and the quality of reproduction of the images is first class," says California astroimager Tony Hallas.

"*Astronomy* is a visual avocation for many of us — who wants to look at inferior reproductions?" Jack Newton adds. "I especially enjoy your 'Reader Gallery,' and as an astrophotographer find it interesting to see 'who's doing what.' "

Astronomer Seth Shostak of the SETI Institute says, "*Astronomy* covers the celestial waterfront, ranging from short news articles that bring me up to date on interesting results outside my research area, to in-depth articles about some of astronomy's biggest questions."

According to Gene Turner, director of Rancho Hidalgo and the Arizona Sky Village, "*Astronomy*'s ability to provide a bridge between science and culture without sacrificing the validity of scientific information is unique within the industry, and nobody does it better."

Says Avi Loeb, professor of astronomy at Harvard University: "I enjoy reading *Astronomy* because of its up-to-date coverage of exciting frontiers in astrophysics. Its refreshing look blends together new discoveries with old facts about the sky and keeps our minds wondering what lies beyond our current knowledge."

"*Astronomy* is a visual avocation for many of us — who wants to look at inferior reproductions?"
— Jack Newton

And a comment by one of our own contributors, Glenn Chaple, sums up *Astronomy*'s mission nicely: "I've been a subscriber to *Astronomy* since its debut. I've watched *Astronomy* evolve from 'the world's most beautiful astronomy magazine' to 'the world's most beautiful *and informative* astronomy magazine.' "

It's just another day in the life of a magazine on a mission.

Yours truly,

David J. Eicher
Editor

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Volume 38, Number 2

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A gallop through Orion the Hunter

Few objects in the cosmos resemble their names, which makes the Horsehead Nebula a remarkable beast. This dense pillar of dust and cold gas appears in silhouette against a glowing star-forming region in Orion. The bright nebula, designated IC 434, absorbs ultraviolet light streaming from the hot star Sigma Orionis and reradiates in the red part of the visible spectrum. Sigma lies just off the top of this image. The Horsehead, Sigma, and IC 434 all lie roughly 1,500 light-years from Earth. Astronomers captured this scene with the Mosaic camera attached to the 0.9-meter telescope on Kitt Peak in Arizona. T. A. Rector (NOAO/AURA/NSF) and the Hubble Heritage Team (STScI/AURA/NASA)

Rainbow reflection madness

Bob Berman is one of my favorite columnists, although selecting a favorite is tough given your current lineup.

Berman's October 2009 column, "A dozen cool facts," was marvelous, but fact number 4, "rainbows don't cast reflections," threw me. The perfunctory explanation of this phenomenon, "because they're not real objects," left me ill-prepared when I tried to share the fact with friends, who had none of it.

Being familiar with Berman's work, they declared that he must have been pulling our legs, as they couldn't conceive that a rainbow can't appear in a mirror. I'm still on the fence about this because you can never find a rainbow when you're looking for one. So if Bob wasn't leading us on, what is the reason a rainbow cannot cast a reflection? — **Gregory Zentz,** Saint Johns, Florida

Nope, I'm not pulling any legs. It's true.

If you and I look at a car, we both see the same object. But a rainbow is a specific set of reflections and refractions within water droplets, essentially appearing on the surface of an invisible cone whose apex is your eye, and your eye alone.

An apparent rainbow reflection in a mirror or on a lake reflects a different rainbow. If the rainbow is nearby (as from a lawn sprinkler), then a mirror just 10 feet to either side will show no reflection of it at all — no matter what the mirror's angle. It'll show the same water droplets but with no rainbow.

This Alaskan rainbow may seem to cast a reflection in the lake, but the reflected rainbow is not the same as the one hanging in the air. The hanging rainbow is visible only at the exact spot where the camera was; the lake actually reflects a different rainbow, made up of a different series of water droplet light refractions. NOAA/Commander John Bortniak

Some readers thought I had implied they couldn't see or capture rainbows using cameras or reflector telescopes. But I never said that photons from rainbows couldn't bounce off glass: In these cases, you're seeing the rainbow, but not simultaneously seeing a reflection of it.

My central point is that you cannot see a rainbow and this same rainbow's reflection. That's because any reflection of an object is simply that object viewed from a different angle — and a rainbow, not being a real three-dimensional object, cannot be viewed from any other angle except exactly where your eye (or camera) is located. — **Bob Berman,** Contributing Editor

A national amateur observatory?

Congratulations on the new *Astronomy* Magazine Observatory you dedicated in New Mexico last September!

Reading about it brought to mind a question I have often considered: Why isn't there an effort to create a "National Amateur Optical Observatory"? With the advent of today's extremely capable remote telescopes, it would seem that such an observatory would be easy to design, build, and operate for American amateurs within a few years. Donations from philanthropic organizations and individuals could surely jump-start the effort.

For the price of a magazine subscription, some good financial management, and a volunteer amateur effort, the amateur community in the United States could keep such an observatory operating. The operation of and access to such a facility might operate much like a university consortium observatory.

Perhaps the time for this discussion is now. — **Bob Patterson,** Dry Ridge, Kentucky

Corrections

On page 67 of the October issue, the chart misidentified the triple star Struve 2816. That system is the second-brightest "star" within the yellow circle, and it sits just below center.

In David H. Levy's November column, "A Bonanza night," he repeats a quote from the TV show asserting that Albert Michelson was the first American to receive a Nobel Prize. The show was incorrect: Theodore Roosevelt was actually the first to do so.

In the November story "Watch as galaxies collide," NGC 5128 (also designated radio source Centaurus A) was described as lying 30 million light-years away. It is actually 10 to 15 million light-years from us. — ***Astronomy*** Editors

We welcome your comments. Send letters to Astronomy *Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

Webtalk

Cosmology 101 video series

In this series, *Astronomy* magazine gives you an overview of important ideas in the area of cosmology. In "Dark Matter," Associate Editor Liz Kruesi introduces you to dark matter, that mysterious stuff that makes up some 90 percent of the universe's mass.

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Podcasts
Senior Editor Michael E. Bakich's weekly series helps you find three notable objects or sky events you can see.

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Strange Universe

by Bob Berman

Why is Neptune so ugly?

Contrast and complexity win out in astronomy's beauty competition.

We're attracted to astronomy for many reasons. It's heady. Mysterious. Awesome. Some of us happily go broke buying fabulous telescopes and gadgets. Some enjoy the math. Yet one major aspect produces no science and little official discussion: beauty.

Like the box-office millions generated by an actress' stunning face, public fascination with breathtaking space objects can create research dollars, as the Hubble web site demonstrates. If astronomy's "beauty factor" is so influential, perhaps it merits discussion — especially during this Valentine month.

Loveliness is, of course, subjective. There are no rules for deciding what makes some objects attractive. Nonetheless, if you show photos of Uranus, Mercury, Saturn, Ganymede, and Titan, and ask friends to choose the most beautiful, everyone picks the same one. Saturn!

Why is this? An art museum is the usual venue for such research. Through the ages, sculptors have chosen subjects they expect buyers to find beautiful. We see the results in museums everywhere — namely, endless statues of young topless women. What a surprise.

Unfortunately, this doesn't help us. But more recent art like the nature panoramas of the Hudson River School, the sunflowers of the Impressionists, and the unstructured modern artists may provide guidance in deciphering the art of the cosmos. Here, we find that uniformity and repetition usually lose out to contrast and complexity.

Uranus and Venus are featureless globes of a single color. Is this why nobody finds them gorgeous? Neptune has a few white and dark spots, but you still wouldn't hang its portrait. Mars sports a blotchy pumpkin hue that takes nobody's breath away.

Jupiter does better with its odd motif of stripes, ovals, and curlicues. It's fascinating. But "fascinating" is not "beautiful." In a quick survey (of 10 people I know, none of whom is normal), no one called it gorgeous. One said Jupiter "lacks a focus." So Saturn remains the only planet that *always* gets gasps at the eyepiece.

Mercury and our Moon's main theme are craters. They're other-worldly. We never tire of exploring lunar features. But is the Moon beautiful? It gets a naked-eye A+ from our panel, especially its dreamy crescents. But a telescope changes things. Scopes strangely alter the Moon from naked-eye "beautiful" to high-mag "exciting."

If astronomy's "beauty factor" is so influential, perhaps it merits discussion.

The ultimate knockouts? Great comets that come along every 15 years or so always are beautiful. So is totality during a solar eclipse. Ditto an animated aurora. These stand alone on the naked-eye medal platform.

Everyone regards star fields as beautiful. But why should white dots on a black background create such a buoyant esthetic response? Are these genetic memories of long-ago skies? Whatever the reason, we're swept away. It scarcely matters whether it's the naked-eye heavens over a desert or the Milky Way through binoculars.

As an observatory director for 30 years, I've noticed that one category always draws oohs and aahs from visitors: globular clusters. Must be that white-dots-on-dark-backdrop motif, once again. By contrast, galaxies are a tough sell through backyard instruments. With photography or CCDs, however, spiral galaxies get elevated to knockout gorgeous. Something about that nautilus design. But forget all other galaxy types.

Our final category, nebulae, hangs in the museum's modern art section. If only they had names that gave clues to their loveliness. Then we'd head for the "Magic Crystal Nebula" and avoid the "Pond Scum Nebula." But we're on our own. Do M42's sweeping gull wings touch your spirit? Does the Ring Nebula look lovely — or merely spooky?

Your call. Scopes under 20 inches paint them all in monochrome gray or else pale green. This art desperately needs a wider palette. Happily, photography and CCDs again come to the rescue. Suddenly, the Orion Nebula explodes with blues, purples, and reds. And then it's inarguably a masterwork.

Conclusion: We're often stirred in similar ways. So while a full explanation of Valentine sky-beauty eludes us, the night's wall-less gallery at least provides consistency. Whatever splendor's secret may be, it keeps the public returning to space, time and again.

But some observers don't seem to need "beautiful." They're happy to stare at the dogs of the night. You'll find them gazing lovingly at light-years of ugly floating rejects like the Eskimo Nebula and M32. Who are these undiscriminating astro-rednecks?

Maybe they're you and me.

Browse the "Strange Universe" archive at www.Astronomy.com/Berman.

Contact me about my strange universe at **skymanbob.com.**

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Secret Sky

by Stephen James O'Meara

Readers search for shadow bands

I share some of my readers' encounters with elusive shadow bands.

In the March and April 2009 issues, I wrote about the mysterious and fascinating forms of shadow bands, which are visible any day (under the right conditions) without a total solar eclipse. Given the response to these articles, non-eclipse shadow bands appear to be a popular subject among *Astronomy* readers as well. Here is a diverse sampling of the reports.

Shadow memories

Brad Bassett of Olympia, Washington, shares that his grandfather, Preston R. Bassett, was also involved in non-eclipse shadow band research. An engineer at Sperry Gyroscope in New York City, Preston worked in the development of large high-intensity searchlights. The job provided him with "opportunities for very unusual observations of the penetration of light through the atmosphere," says Brad.

Preston first noticed the shadow band phenomenon during experiments with a large searchlight whose beam projected onto a screen 2 miles (3 kilometers) distant. Both searchlight and observer were 200 feet (61 meters) above the intervening terrain, so the light shone unimpeded through the open air. Often, Preston would see "wavy dark bands pass across the illuminated field." Sometimes the bands were "sharp and dark," and at other times they were "thin and light."

With no wind, the bands would "pass vertically upwards" at a rate of about 1 or 2 feet (30 or 60 centimeters) per second. With wind, they would "dance or frisk quite rapidly and irregularly in the direction of the wind, but always with a noticeable upward component." The bands moved with their long axis perpendicular to their apparent motion and were irregularly spaced and noticeably convex in the direction of travel.

Preston's full results appear in a paper titled "Shadow Bands and Searchlights," published in a 1925 issue of *Popular Astronomy*. You can e-mail Brad Bassett at brad_eld@yahoo.com.

Brad Bassett's grandfather, Preston R. Bassett, frequently observed shadow bands during his work with high-intensity searchlights, even publishing a paper on the subject more than 80 years ago. Courtesy Brad Bassett

Shadow bands, Fresnel zones

Tim Stoffel, a broadcast engineer from Reno, Nevada, found the shadow band articles of great interest. He realized they also relate to something microwave communication engineers have known about for decades: Fresnel zones.

If an object lies in the path of a microwave signal and nearly or partially obstructs the beam, the object's edge can cause some of the microwaves to bend along its surface. A smooth surface, Stoffel explains, will set up a few zones of addition and cancellation of the microwave energy, but will not greatly affect the signal's main beam.

"But a sharp edge, like the roof of King's College as mentioned in your article," Stoffel notes, causes the microwave signal to bend considerably, setting up a large number of addition and cancellation zones. "Again, these are off the signal's main beam, and in some cases can concentrate the signal to levels higher than in the main beam. This is called 'edge diffraction,' and the resulting areas of addition and cancellation are called 'Fresnel zones.'

Tim Stoffel knew he could relate shadow bands to the phenomenon known as Fresnel zones, thanks to his work as a microwave communication engineer. Courtesy Tim Stoffel

"A diffracting edge a long ways away, like on the horizon during sunset," Stoffel continues, "may set up only small Fresnel zones at a distance of a number of miles. It's likely that these light-wave Fresnel zones may be observable as the 'shadow bands' you describe in your article. They will also move as your article describes because the electromagnetic energy source (the Sun) is moving. Now to this effect, add the factor of atmospheric instability causing more bending of light waves, and you get the dancing or mottled effect you describe in your article."

Stoffel says he'll now be on the lookout for non-eclipse shadow bands. E-mail him at tim@lionlamb.us.

A curious experiment

In 1998, Terry L. McCormick taught his Pennsylvania science class how to view a visible-light spectrum of the Sun. He set up a glass prism in the back of the lab and angled it using a mirror to project the resulting spectrum onto a white board at the front of the adjoining classroom. "The display," he says, "was

large, brilliantly colored, and bright in the darkened room."

While lecturing, however, he noticed how distinct, dark bands would form in parallel and seemingly migrate across the spectrum whenever a cloud advanced across the Sun's face, before fully occulting it. The bands formed again as the cloud moved on, re-exposing the Sun's rim. "As an amateur astro buff," McCormick says, "I thought immediately of solar-eclipse shadow bands."

The effect was so pronounced that McCormick wonders if the shadows are distinct interference bands resulting from the Sun's disk narrowing to a "thin 'slit' by the occluding object. Any distortion of those bands would be the result of atmospheric turbulence."

McCormick says he'd love others to try his experiment and to hear their results. Contact him at zormsk@gmail.com.

Shadow bands, artificially shown in this composite photo of an Egyptian backdrop, normally appear faintly on the ground and can be difficult for even advanced observers to spot. Stephen James O'Meara

Success, finally!

In October 2007, Bob Minor of Berkeley, California, looked for non-eclipse shadow bands on three mornings on a family trip. They stayed in a cabin about 40 miles west of the White Mountains in the Sierra Nevada range.

On the first two mornings, Minor was prepared to videotape and photograph the potential shadow bands rising up the cabin's vertical wall. But he saw nothing, noting some haze on the horizon and a moderate wind.

On the third morning, however, "with still camera in hand (but no video), under crystal clear skies and no wind, the shadow bands were fantastic. I called to my wife, Jeanie, to come out to see them, but she did not make it in time."

Minor notes that the sunrise shadow bands were of higher contrast than those he saw during the 2006 total solar eclipse in Egypt. The parallel bands on the cabin occurred about 4 to 6 inches (10 to 15 cm) apart, moved at a constant rate, and lasted 1 to 2 minutes.

"And just like during an eclipse," Minor quips, "even though I had the camera in my hand, I did not shoot a single image in the excitement of the moment!" Feel free to e-mail Minor at rhminor@comcast.net.

Bob Minor, shown here in China during the 2008 solar eclipse, ultimately found success in his search for non-eclipse shadow bands in California. Jeanie Minor

Hot shadows

"I don't know if this will help your shadow band investigation," John Goodwin writes, "but several years ago, after heathen smokers at Kennedy Space Center were banished to the parking lots (I being one of them), I would notice shadow bands moving across the black pavement when the Sun was high overhead."

Goodwin reasoned the effect must have been due to heated air coming off the pavement and moved along by a gentle breeze. The shadows, he says, resulted from the dramatic difference in density between the heated, still air and the ambient, moving air. "Humidity most likely played a part in this," he says. You can reach Goodwin at jgoodwin48@hotmail.com.

Again, I'd like to thank everyone who e-mailed me with observations. They're always a pleasure to read, and I look forward to devoting future columns to more reader observations of the wonders in both the day and night skies.

Browse the "Secret Sky" archive at www.Astronomy.com/OMeara.

Heavyweight champ Scientists at Lawrence Berkeley National Laboratory have confirmed the decade-old Russian discovery of superheavy element 114.

For the latest news on space discoveries, spacecraft missions, and sky events, visit **Astronomy.com/news**

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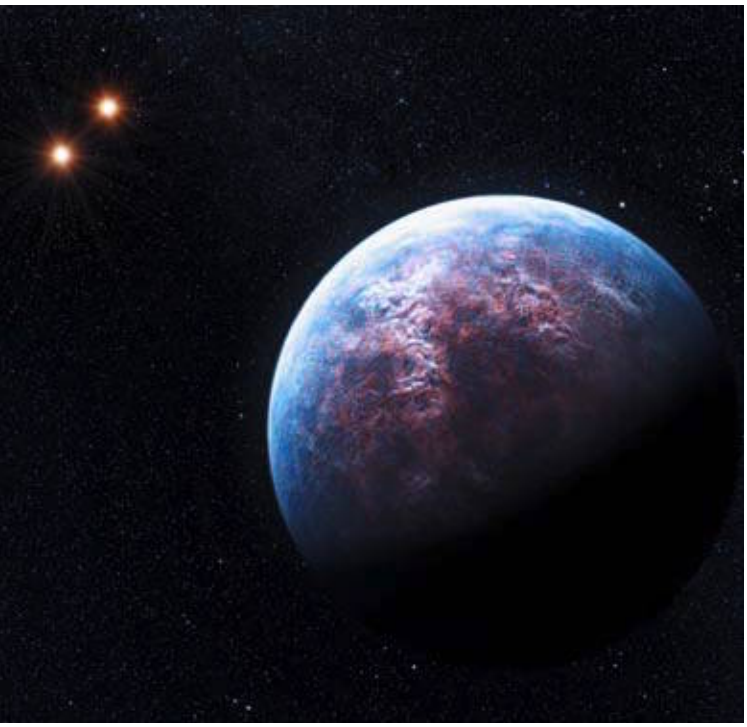


New planet. The 6-Earth-mass exoplanet seen in this artist's impression circles the low-mass star Gliese 667 C. (Two other members of this triple-star system appear in the background.) This newly discovered planet is one of 32 announced recently by European astronomers. ESO

Exoplanet tally tops 400

On October 19, European astronomers announced their discovery of 32 new planets beyond our solar system. This bonanza pushes the number of known exoplanets past 400.

The researchers discovered the planets with the High Accuracy Radial Velocity Planet Searcher (HARPS), a spectrograph attached to the European Southern Observatory's 3.6-meter telescope in Chile. HARPS recently completed its initial 5-year program, says Geneva Observatory astronomer Stephane Udry, who announced the new discoveries at an exoplanet conference in Porto, Portugal.

The spectrograph measures small changes in a star's radial velocity caused by the gentle gravitational pull from an orbiting planet. HARPS can detect velocity changes as small as 2.2 mph (3.5 km/h), a slow walking pace. The 32 new planets bring HARPS's total haul to more than 75 in 30 different planetary systems.

The instrument's precision has helped astronomers find some of the smallest known exoplanets, a few with masses just a few times greater than Earth's. Of the 28 planets with masses less than 20 Earth masses, HARPS has found 24. Some of them lie within their host stars' habitable zones, where water could exist as a liquid.

Although the researchers have wrapped up the first phase of their exoplanet program, their search goes on. They expect to announce even more new planets circling Sun-like and smaller stars within the next several months. — **RICHARD TALCOTT**

20 Ares makes its maiden flight

21 A smashing success

22 Apophis-Earth impact chance downgraded

23 A flare for the dramatic

24 Saturn has enormous outer dust ring

Early bloomer. JKCS041 — shown in a composite X-ray, optical, and infrared image — is the most distant galaxy cluster known. X-ray: NASA/CXC/INAF/S. Andreon et al.; Optical: DSS, ESO/VLT; Infrared: DSS

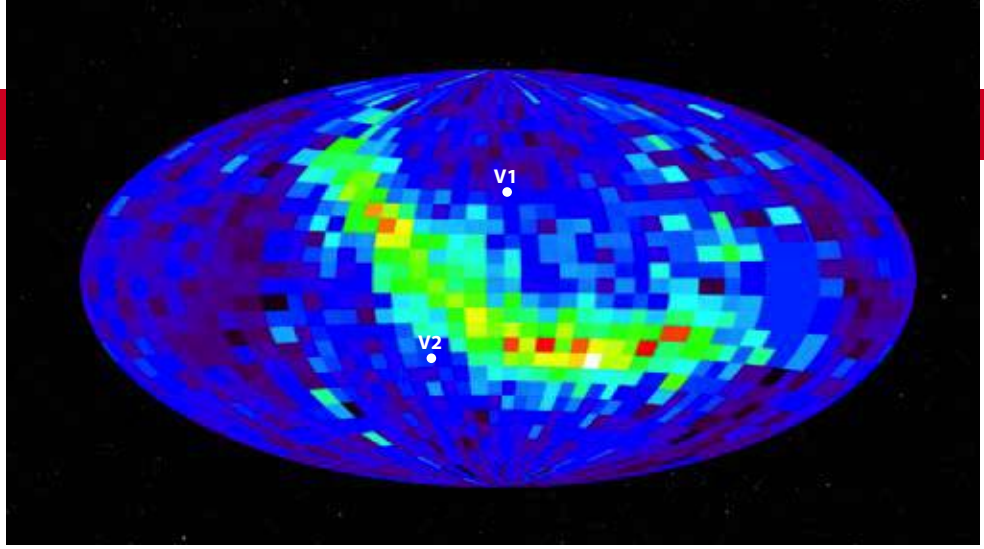
Scientists see distant galaxy cluster

Astronomers using the Chandra X-ray Observatory announced October 22 the discovery of the most distant galaxy cluster. The team combined X-ray data with optical and infrared to find galaxy cluster JKCS041, about 10.2 billion light-years away. The study also appeared in the December *Astronomy & Astrophysics*.

While astronomers with the U.K. Infrared Telescope originally found the object, they needed additional infrared and optical data to pinpoint a distance. Then the X-ray data showed hot gas between the galaxies — as expected in a galaxy cluster.

The team doesn't expect to find many more galaxy clusters at distances farther than JKCS041. "We don't think gravity can work fast enough to make galaxy clusters much earlier," says lead author Stefano Andreon of the National Institute for Astrophysics in Milan, Italy. The universe tends to assemble smaller objects first. These structures then combine into larger ones.

Astronomers estimate JKCS041 existed about 3.5 billion years into the universe's history. This is at the edge of when scientists think galaxy clusters began forming. — **LIZ KRUESI**



Surprise! **NASA's IBEX spacecraft mapped a ribbon of energetic neutral atoms across the sky where the heliosphere meets the rest of space. Interestingly, neither Voyager spacecraft (V1 and V2) — each of which has crossed the heliopause — detected the ribbon.** NASA/Goddard Space Flight Center Scientific Visualization Studio

Astronomers find ribbon at solar system's edge

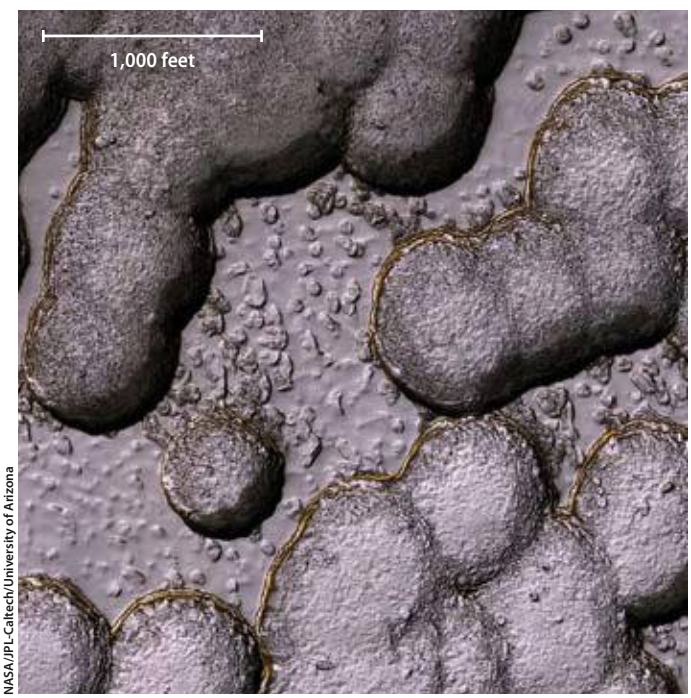
The Interstellar Boundary Explorer (IBEX) spacecraft launched October 19, 2008, to study the interactions that occur where our solar system's edge and interstellar space meet. On October 15 in the journal *Science*, the IBEX team published five papers describing the first all-sky IBEX maps. But the maps don't look like astronomers expected. Instead, IBEX observed extremely bright mysterious emissions along a narrow ribbon crossing the sky.

The Sun spews out fast-moving charged particles in all directions, which collectively are called the solar wind. The solar wind blows out a protective bubble, called the heliosphere. The heliosphere meets up with particles moving the other direction because the Sun is moving around the galaxy's center and therefore running into a wind of particles. Interactions where the solar wind meets the incoming particles create energetic neutral atoms (ENAs), which IBEX can detect.

Computational models predicted IBEX would see a 20 to 30 percent variation in ENAs across the sky. Instead, the craft detected a narrow band with emissions some 2 to 3 times as strong as those in adjacent regions.

Astronomers aren't sure what is causing the ribbon, nor do they know how long it will last. One possibility is that magnetic fields outside our solar system shape the heliosphere.

This data came from 6 months of observations, and the IBEX team intends to create a new global map every 6 months. **— L. K.**



NASA/JPL-Caltech/University of Arizona

A slice of swiss on Mars

Say cheese. **The south pole of Mars is a winter wonderland — even in summer. Summer's heat never completely removes the pole's frozen carbon dioxide (dry ice). In this region, circular and oval depressions break up the otherwise relatively smooth ice, creating a pattern scientists call "swiss cheese" terrain. Because the Sun never climbs high in the polar sky, the steep walls of the pits receive far more sunlight than the higher flat areas in between. Each martian summer, the ice "sublimates" (evaporates directly to gas) and these walls retreat by several yards (meters). — R. T.**

QUICK TAKES

WHITE HOUSE STAR PARTY
President Obama hosted a star party for 150 D.C.-area students October 7. Amateur astronomers set up more than 20 telescopes on the White House's south lawn.

SATURN GAINS A MOON
The Cassini spacecraft's camera has discovered a new moon orbiting within the outer part of the planet's bright B ring.

NO YEAST NEEDED
Peter Scheirich and colleagues in the Czech Republic found that asteroid 2008 TC_3, which crashed in Sudan in 2008, had the form of a loaf of walnut-raisin bread.

AN AIRY NEUTRON STAR
The Chandra X-ray Observatory has discovered an ultrathin carbon atmosphere around the neutron star at the center of the Cassiopeia A supernova remnant.

SQUYRES A WINNER
The American Astronomical Society awarded Steven Squyres, principal investigator for the Mars rovers, its 2009 Carl Sagan Medal for excellence in communication.

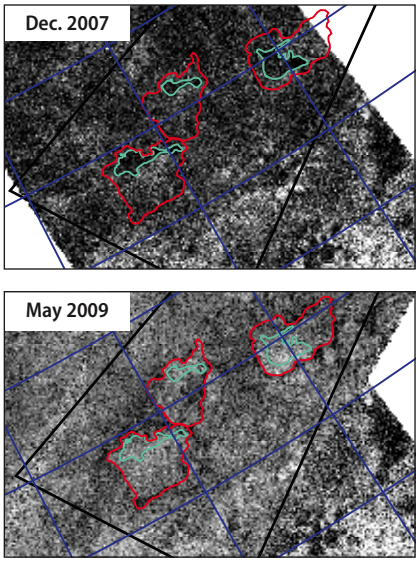
"SEEING" BLACK HOLES
Rochester Institute of Technology scientists have received $2.9 million from the National Science Foundation to study the intense gravity that surrounds black holes.

CoRoT LIVES ON
The French Space Agency has extended the CoRoT mission until March 2013. The spacecraft will continue to search for exoplanets and study stellar oscillations.

GOLDEN OPPORTUNITY
The National Science Foundation awarded $29 million to the University of California, Berkeley, to design the world's deepest laboratory, which will be located in the former Homestake gold mine in Lead, South Dakota.

CALL ME HERSE, BY JOVE
The International Astronomical Union has approved the name "Herse" for Jupiter's 50th moon. In mythology, Herse is a daughter of Zeus and Selene.

CHUBBY MONOPOLES
A National Institute of Standards and Technology team has created a molecule-sized compound that behaves like a magnetic monopole should. The compound may help scientists understand their smaller, still-theoretical cousins.



Disappearing lakes. Radar images of Titan's south polar region show lakes apparently evaporating. In a December 2007 image (top), cyan outlines filled lakes, and red marks broader depressions. By May 2009 (above), the lakes had disappeared. NASA/JPL

Seasons change on Saturn's Titan

The hydrocarbon lakes on Saturn's largest moon, Titan, don't seem to be permanent features. Using the Cassini spacecraft's radar instrument, planetary scientists have watched some lakes disappear from the south polar region as summer on Titan neared its end.

Two teams of researchers analyzed multiple radar images of the polar region taken since Cassini arrived at Saturn in 2004. Alex Hayes of Caltech and Jonathan Lunine of the University of Rome Tor Vergata reported their related studies October 6 at the American Astronomical Society's Division for Planetary Sciences meeting in Fajardo, Puerto Rico.

Observations of the south polar region's largest lake, Ontario Lacus, show that its shoreline receded dramatically between July 2004 and July 2009. Just as impressive, several smaller lakes disappeared in little more than 1 Earth year.

Hayes and Lunine believe the liquid hydrocarbons simply evaporated under the late summer Sun. If true, the evaporation rate from the lakes would have to be around 3 feet (1 meter) per year. Scientists will continue to monitor these areas with Cassini's radar to see if any other surface changes take place. — **R. T.**

Ares makes its maiden flight

On October 28, the world got a 6-minute preview of NASA's possible future in human spaceflight. At 11:30 A.M., an Ares I-X test vehicle roared off Launch Pad 39B at Kennedy Space Center in Florida. A preliminary look at data sent back by the 700 onboard sensors shows the rocket performed about as well as expected.

The 327-foot-tall (100 meters) test vehicle generated 2.6 million pounds of thrust that accelerated the rocket to nearly 5 times the speed of sound. Approximately 2 minutes into the flight, the rocket's first stage burned out as planned.

The upper stages of the vehicle continued to an altitude of 28 miles (45 kilometers) before falling back through the atmosphere and splashing down in the Atlantic Ocean some 150 miles (240 km) downrange.

The test vehicle was similar in size and mass to an actual Ares I rocket and Orion crew module, but only the first stage included working hardware. NASA powered the vehicle with a single, four-segment reusable solid rocket booster from the space shuttle inventory. Engineers modified this booster to include a fifth inactive segment to simulate the Ares I five-segment booster.

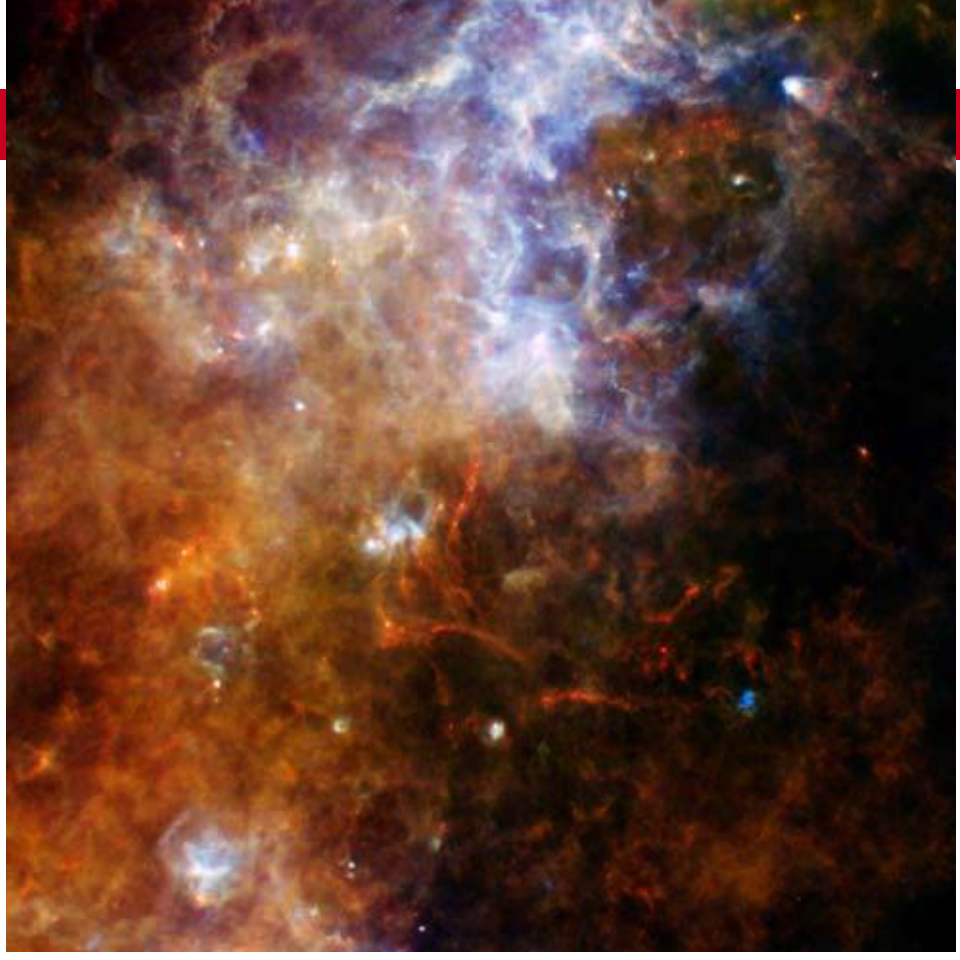
The test vehicle also used a set of three new parachutes to bring the first stage back for inspection. The vehicle's upper stage, Orion crew module, and launch abort system were all mock-ups used to simulate the entire spacecraft.

Blastoff. The Ares I-X test vehicle rockets into a blue sky above Kennedy Space Center October 28. This initial test flight lasted 6 minutes and provided NASA with crucial engineering data. NASA/Sandra Joseph and Kevin O'Connell

The only obvious glitch involved the new parachutes. One of the chutes failed to inflate, and its failure caused a second chute to inflate only halfway. The booster thus hit the Atlantic much harder than planned. Still, the engineers were happy with the information they got from the flight, and they expect to fix the problem without difficulty.

NASA hopes the Ares I and its larger sibling, the Ares V, one day will take humans back to the Moon (see "How we'll return to the Moon," August 2009) and then to Mars. The name says it all: Ares is the Greek name for the Roman god Mars. — **R. T.**

Ocean booster. Divers approach the floating first stage of the Ares I-X test vehicle in the Atlantic Ocean. The *Freedom Star* recovery ship lurks in the background. United Space Alliance



Herschel reveals details in galaxy's plane

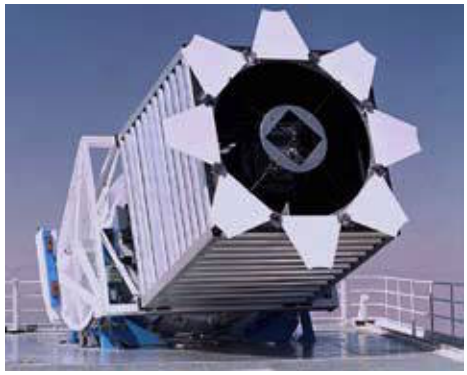
Way to glow. While verifying the European Space Agency Herschel Space Telescope's two photometers, researchers trained the scope on this 2° by 2° field in the constellation Crux. In this region, Herschel imaged more detail than ever before seen. The telescope detected gas clouds that previous infrared telescopes had not found. Such gas clouds harbor the early stages of star formation, where the material is condensing to form protostars. ESA released this image October 2. — **L. K.** ESA and the SPIRE & PACS consortia

Scientists begin new dark energy survey

On October 1, astronomers with the Sloan Digital Sky Survey III (SDSS-III) announced that their dark energy survey began taking data on the evening of September 14. The Baryon Oscillation Spectroscopic Survey (BOSS) is looking for large-scale variations in cosmic structure due to dark energy's effects.

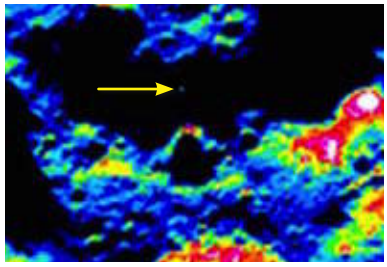
These wavelike variations originated as small density fluctuations in the cosmic microwave background — the Big Bang's afterglow radiation. "When the universe was only a few hundred thousand years old, the universe cooled enough to halt the waves, leaving a signature 500 million light-years in length," says Nikhil Padmanabhan, a BOSS researcher.

"We can see these frozen waves in the distribution of galaxies today," adds Daniel Eisenstein, director of the SDSS-III at the University of Arizona. Scientists can measure the waves' sizes at different cosmic times to gain hints on how dark energy has affected the universe's expansion.



On the hunt. The Baryon Oscillation Spectroscopic Survey will use the Sloan 2.5-meter telescope to determine the distances to some 1.5 million objects and map cosmic geometry. Sloan Digital Sky Survey

The first night's data set includes detailed spectra of some 1,000 galaxies and quasars — active galaxies powered by central supermassive black holes. By the time the project is complete (in 2014), BOSS astronomers plan to have captured spectra of about 1.4 million galaxies and 160,000 quasars. — **L. K.**



Impact flash. The mid-infrared camera on LCROSS captured the thermal flash (arrow) created by the Centaur upper stage's impact. In the image, white represents temperatures of about 95° F (35° C); red, 65° F (18° C); dark blue, –49° F (–45° C); and black, below –58° F (–50° C). NASA

A smashing success

On October 9, NASA's Lunar CRater Observation and Sensing Satellite (LCROSS) blasted a hole in the Moon. The impact occurred about 4 minutes after the probe's traveling companion, its spent Centaur upper stage rocket, crashed in nearly the same spot — the permanently shadowed Cabeus Crater near the Moon's south pole.

Five weeks later, on November 13, LCROSS principal investigator Anthony Colaprete of NASA's Ames Research Center in Moffett Field, California, announced that the probe had discovered water in the vapor and debris plumes ejected by the Centaur's impact. Lunar water would be invaluable to future human explorers because they would not need to bring any with them.

LCROSS and the Centaur separated about 54,000 miles (87,000 kilometers) above the Moon's surface at approximately 9:50 P.M. EDT October 8. The Centaur hit pay dirt shortly after 7:31 A.M. EDT (October 9) at about 55,000 mph (89,000 km/h). LCROSS viewed the results for about 4 minutes before it, too, crashed.

The nine LCROSS instruments, which included cameras and spectrometers, observed a debris plume mere seconds after recording the impact flash. Unfortunately, the plume's brightness was near the low end of predictions and too faint for backyard observers to see.

LCROSS continued to return data until the final seconds before it crashed. Its final mid- and near-infrared images revealed Cabeus' floor and the fresh Centaur impact crater, which measured 92 feet (28 meters) across. — **R. T.**

Webb rolls along German engineers have completed a test model of the Near-Infrared Spectrograph, one of four instruments that will fly on the James Webb Space Telescope.

Apophis-Earth impact chance downgraded

Scientists have refined the chances that asteroid Apophis will veer near (or into) Earth. They announced the new values October 8 at the Division for Planetary Sciences meeting.

Apophis is the asteroid that was in the news about 5 years ago because astronomers predicted there was a chance as high as 1 in 37 of it colliding with Earth in 2029. Scientists quickly revised that prediction. Now they say there's no chance the asteroid will hit our home planet in 2029.

There is a possibility that it could pass through a gravitational "keyhole." This is a window (about 1,970 feet [600 meters] in diameter) where the gravitational forces would set up a collision with Earth. According to David Tholen of the University of Hawaii and Steven Chesley of NASA's JPL, the chance of such a collision is 1 in 250,000 in 2036.

Following additional observations and modeling, Tholen's group estimates Apophis could pass through another keyhole in 2067, which would send it on a 2068 collision course with Earth. This keyhole, however, is just 6 feet (2m) in diameter. The chance of impact is even smaller than 2036's chances — about 1 in 333,000. — **L. K.**

NASA/ESA/Jesús Maíz Apellániz (Instituto de Astrofísica de Andalucía, Spain)

Jewel Box. Hubble captured this multiwavelength view of the core of Crux's Jewel Box Cluster (NGC 4755) shortly before last year's servicing mission.

Jewels of the Southern Cross

The Hubble Space Telescope's Wide Field and Planetary Camera 2 took hundreds of thousands of images during its 15 years in space. But astronomers saved one of the best for near the end: a multiwavelength look at the Jewel Box Cluster (NGC 4755) in the southern constellation Crux.

Hubble's view of the Jewel Box's core marks the first photo ever of an open star cluster from far ultraviolet to near-infrared wavelengths. The image shows several pale-blue supergiant stars, one bloated red supergiant, and a cornucopia of fainter but still-colorful stars. — **R. T.**

BRIEFCASE

Photographers, rejoice!

Half of the 2009 Nobel Prize in physics was awarded October 6 to Willard Boyle and George Smith for the invention of a digital sensor — a CCD. This is the backbone of all digital imaging used in telescopes, spacecraft, and your subcompact digital camera. The pair invented the first CCD in 1969 — after just an hour of brainstorming, according to Boyle. — L. K.

Extremely primitive material found

Planetary scientists say dust samples from the Grigg-Skjellerup comet contain "ultra-primitive" material. In April 2003, NASA aircraft collected dust in Earth's upper atmosphere shortly after the planet passed through the comet's dust trail. Some of the material predates the solar system's formation. The scientists reported their finding online October 8 in *Earth and Planetary Science Letters*. — L. K.

Saturn's moons discolored

Paul Schenk of the Lunar and Planetary Institute presented new global color maps of Saturn's five innermost large icy satellites October 5 at the Division for Planetary Sciences meeting in Fajardo, Puerto Rico. Four of the moons show color asymmetries, and three show equatorial banding. Particles within the Saturn system likely have significant effects on the surfaces of the satellites. — L. K.

25 years ago in *Astronomy*

February 1985

Astronomy's February 1985 issue featured "Through Monster Eyes," an overview of future huge telescopes. Science writer Dennis Mammana wrote about the Multiple Mirror Telescope (MMT), which, as its name suggests, used the new (at that time) technology of combining the light from multiple mirrors. This creates essentially one large primary instrument.

Mammana compared the MMT to one possible future scope in particular: the National New Technology Telescope (NNTT). Unfortunately, the NNTT never made it past the planning stage, but that didn't stop other gigantic telescopes and technological innovations.

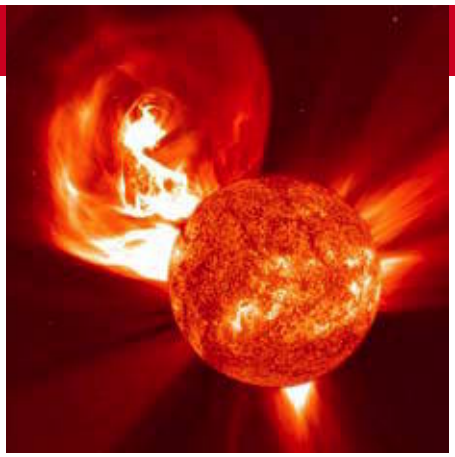
The European Very Large Telescope incorporates four 8.2-meter scopes, and the Large Binocular Telescope uses two 8.4-meter mirrors. Now astronomers are planning for two huge multi-mirrored scopes to see first light in 2018: the Giant Magellan Telescope (working 24.5-meter primary) and the Thirty Meter Telescope.

February 2000

10 years ago in *Astronomy*

In the February 2000 issue of *Astronomy*, frequent contributor Robert Zimmerman wrote about the mysterious star Eta Carinae in "Scoping out the monster star." This star is one of the heaviest known, at more than 100 solar masses. It's also an unpredictable variable star that's had plenty of outbursts in its recorded history.

Zimmerman wrote that understanding Eta Carinae's behavior is crucial, and its "future activity might even tell us why, where, and when stars go boom." That's because many astronomers think Eta Carinae shows characteristics expected by a star that will explode as a supernova. But no one knows exactly when. — **L. K.**



Astronaut beware. Coronal mass ejections like this one from January 4, 2002, can produce energetic protons that could endanger astronauts. MESSENGER spacecraft observations of neutrons produced by a normal solar flare suggest a link to the high-energy protons. SOHO (ESA and NASA)

A flare for the dramatic

On December 31, 2007, the Sun flared to life after a fairly lengthy slumber. By all accounts, this solar flare was average. But an instrument onboard NASA's MESSENGER spacecraft gave astronomers an unprecedented view that may help predict the Sun's worst outbursts.

In a paper to be published in an upcoming issue of the *Journal of Geophysical Research*, William Feldman of the Planetary Science Institute in Tucson, Arizona, and colleagues report on their flare observations. The Mercury-bound MESSENGER spacecraft's neutron spectrometer detected neutrons from the flare. It marked the first time astronomers had seen these subatomic particles from such a small flare. At the time, MESSENGER was about half of Earth's distance from the Sun.

Before this discovery, spectrometers on Earth or in near-Earth orbit had detected neutrons only from the most powerful flares. These neutron bursts typically last only 50 or 60 seconds. "But we recorded neutrons from this flare over a period of 6 to 10 hours," says Feldman. "That tells us that at least some moderate-sized flares continuously produce high-energy neutrons in the solar corona."

Feldman says these neutrons eventually decay into protons, which can be accelerated into interplanetary space by the shock waves produced by coronal mass ejections. Such energetic protons not only can damage Earth-orbiting satellites, but they also pose a risk to astronauts in Earth orbit and beyond.

The goal is to understand which solar flares and coronal mass ejections will generate dangerous levels of high-energy protons. Feldman hopes MESSENGER will observe many more flares in the coming years and help researchers realize this goal. — **R. T.**

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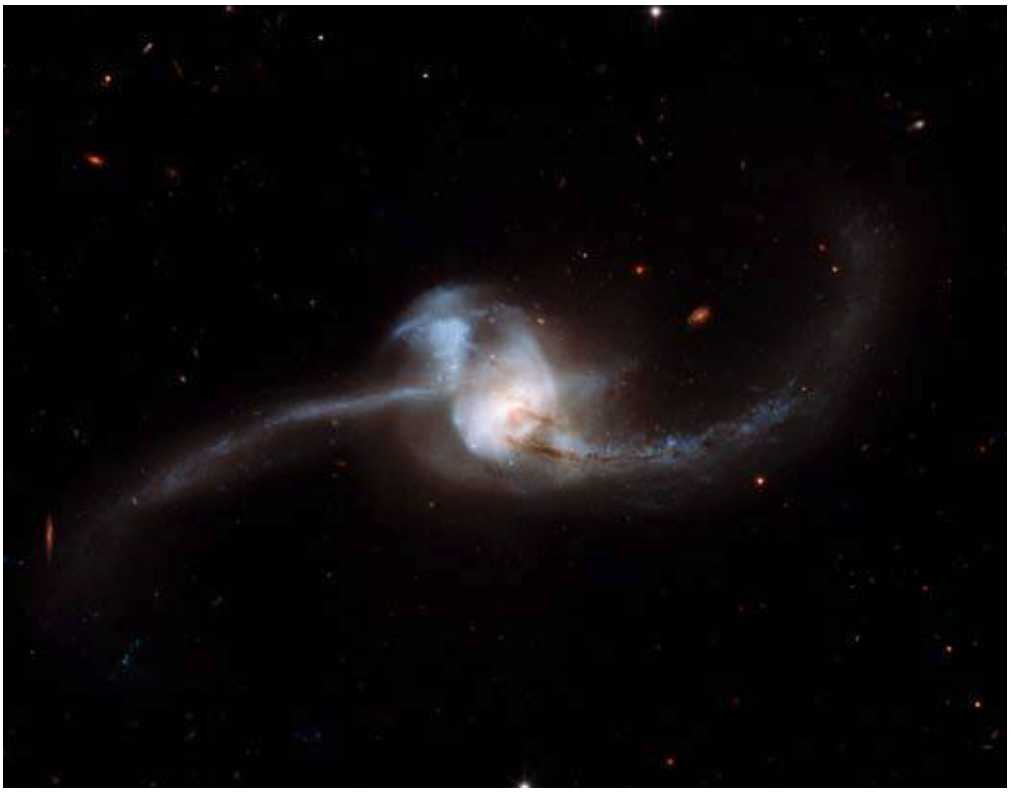
Oxygen for life Richard Greenberg of the University of Arizona estimates that the ocean on Jupiter's moon Europa likely contains more oxygen than Earth's oceans — enough to support life.



NASA, ESA and A. Evans (Stony Brook University, New York, University of Virginia, and National Radio Astronomy Observatory, Charlottesville, USA)

Galactic mergers offer a lovely show

Beautiful disaster. Two spiral galaxies have almost completed merging into the massive galaxy NGC 2623. Their separate centers have already combined into one central nucleus. The tidal tails — evidence of extreme gravitational forces — are evident in this Hubble Space Telescope image, released October 12. At least 100 bright star clusters are in the lower tail. Such star clusters are common in merging galaxies as colliding material compresses and initiates star formation. — L. K.

Minerals may have "rained" onto Earth

Precious metals glisten beautifully, and now it seems they may have an equally illustrious past. A study in the October 18 *Nature Geoscience* suggests the majority of minerals and precious metals on Earth have extraterrestrial origins.

William McDonough of the University of Maryland and James Brenan of the University of Toronto re-created the conditions of early Earth, when enormous temperatures and pressures transformed a mixture of rock and iron into a rocky planet with an iron core. They found few minerals left over in the rock because the extreme temperature "would have completely stripped any precious metals from the rocky crust and deposited them in the core," explains Brenan.

Why does Earth's rock have detectable concentrations of precious metals? "Our results indicate that they must have been added back, likely by a 'rain' of extraterrestrial debris, such as comets and meteorites," explains Brenan.

— BILL ANDREWS

Saturn has enormous outer dust ring

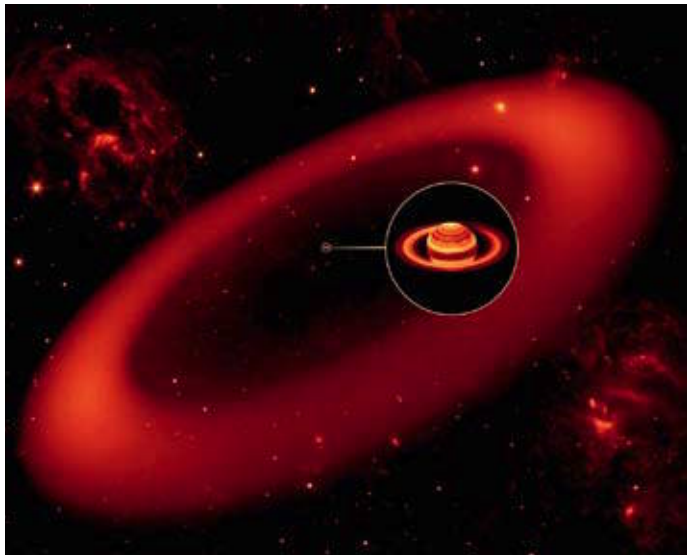
Using the Spitzer Space Telescope, astronomers have discovered an enormous dust ring around Saturn. The planet's moon Phoebe orbits within the ring and likely contributes material to it. Anne Verbiscer of the University of Virginia at Charlottesville announced her team's discovery October 6 at the Division for Planetary Sciences meeting in Fajardo, Puerto Rico.

This ring is the largest known planetary ring in the solar system. Its inner edge starts around 128 Saturn radii from the planet and extends to 207 Saturn radii. It's some 40 times Saturn's radius thick, which matches Pheobe's vertical motion along its orbit. The ring seems to be inclined 27° to Saturn's equatorial plane.

The newly discovered ring is about 100 times larger than Saturn's main ring system. That system is also aligned with Saturn, which means a different mechanism must help form this newly found ring.

The team believes particle impacts with Phoebe produced debris that remains in a thick disk around the satellite's orbit, therefore creating this huge ring. Douglas Hamilton, a co-author at the University of Maryland at College Park, adds that if you were standing within the ring, the density is such that you'd be hit by a particle about once per minute.

The team also published its finding in the October 7 issue of *Nature*. **— L. K.**



New bling. Saturn's newly discovered ring is much larger (about 100 times) than the planet and its main ring system, as illustrated here. The huge ring has a low particle density and has been detected only in infrared radiation. This ring is the largest yet known in the solar system. NASA/JPL-Caltech/Keck

Make Sense of Black Holes

Explore the fascinating science behind one of the most profound aspects of our universe in these 12 lectures delivered by an expert astronomer.

Imagine a region in space where the force of gravity is so strong that nothing—not even light—can escape. A region with physical conditions so extreme that they have not yet been reproduced in any terrestrial laboratory. A region so dense that an object as tiny as a walnut would have the same mass as our entire planet.

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Nearly everyone has heard of black holes, but few people outside of complex scientific fields understand their true nature and their implications for our universe. **Black Holes Explained** finally makes this awe-inspiring cosmological subject graspable, with 12 lavishly illustrated lectures taught by distinguished astronomer and award-winning Professor Alex Filippenko.

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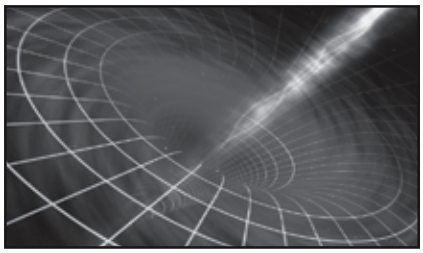

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About Your Professor

Dr. Alex Filippenko is the Richard and Rhoda Goldman Distinguished Professor in the Physical Sciences at the University of California, Berkeley. A member of the National Academy of Sciences, Professor Filippenko is coauthor of *The Cosmos: Astronomy in the New Millennium*, winner of the Texty Excellence Award for best new textbook in the physical sciences.

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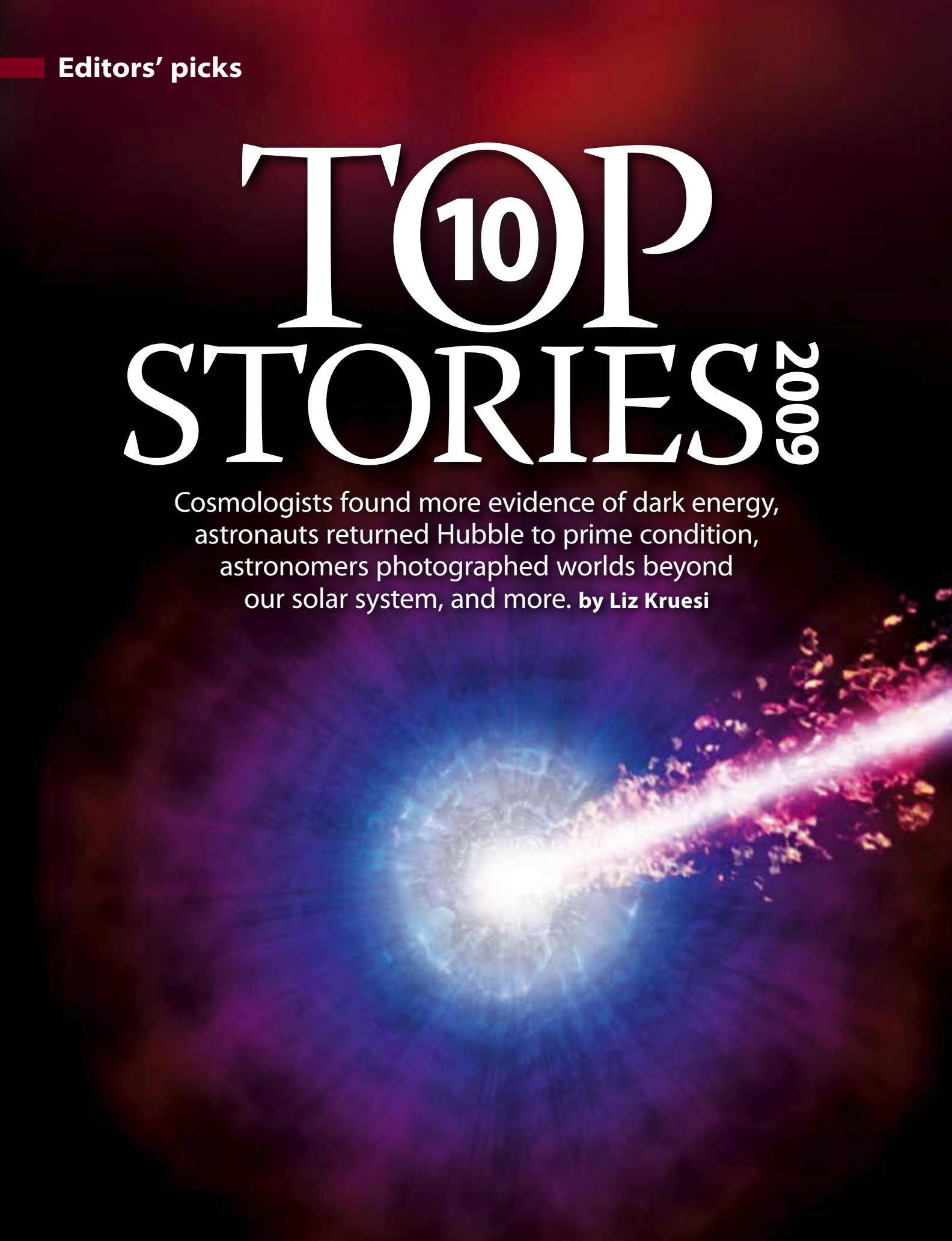
TOP 10 STORIES 2009

Cosmologists found more evidence of dark energy, astronauts returned Hubble to prime condition, astronomers photographed worlds beyond our solar system, and more. **by Liz Kruesi**



In the past year, astronomers launched missions to study the universe's relic radiation, our galaxy's cold dust, and Earth's nearest neighbor. We witnessed a solar system object's collision with Jupiter — and it caused concern around the world. 2009 also saw an international celebration of astronomy that encouraged people all over the globe to look up.

While looking up, astronomers discovered the smallest planet yet around a normal star, and they launched a satellite to find hundreds more. Discoveries of the most distant blast known and a huge haul of gamma-ray objects add to the big year.

Astronomy's editors ranked these and other findings to put together this list of 2009's top 10 stories.

10 Going to extremes

On April 23, the Swift X-ray satellite witnessed a record-breaking gamma-ray burst (GRB) — a blast that signals the explosive death of a massive star. Swift saw 10 seconds of gamma rays followed by an X-ray afterglow. Such afterglows occur because the star's gamma-ray jets plow through surrounding material that the star previously shed. As they barrel through, the gamma rays transfer energy to the material and cause it to radiate.

After localizing its position with Swift, and then performing follow-up observations with multiple ground-based observatories, scientists determined that the burst, called GRB 090423, occurred when the universe was just 630 million years old. (That corresponds to a redshift of 8.2.)

The recorded redshift makes this GRB the most distant blast yet seen. The object's redshift corresponds to when the universe was just one-twentieth of its current age. Astronomers believe the first stars began forming around 200 million years after the Big Bang, and GRB 090423's progenitor star brings them closer to that time period.

It also gives astronomers clues about the little-understood cosmic Dark Ages, and the following "reionization" epoch.

One of 2009's biggest stories occured April 23 when the Swift X-ray satellite discovered a gamma-ray burst (GRB) so far away that it's from when the universe was just 630 million years old. The GRB, illustrated here, broke the record for the most distant blast discovered.
Astronomy: Roen Kelly

9 Closing in on cosmic-ray sources

Starburst galaxy M82 is a source of high-energy gamma rays, and also cosmic rays, say researchers. This discovery marks the first time scientists have detected gamma rays from a starburst galaxy. NASA/ESA/CXC/JPL-Caltech

For decades scientists have theorized that blast waves from exploding stars called supernovae accelerate cosmic rays to extreme speeds. In November, two research groups with two gamma-ray observatories (VERITAS and the Fermi Gamma-ray Space Telescope) announced that they had discovered gamma rays from starburst galaxy M82. Cosmic-ray interactions often produce gamma rays. Because starburst galaxies contain regions of active star formation and death, this finding shows scientists are closing in on cosmic-ray sources.

Cosmic rays are high-energy protons and other incoming charged particles that bombard Earth from all directions. Since discovering them almost a century ago, scientists have wondered where cosmic rays originate. Finding the answer is not as easy as it sounds. The particles have a magnetic charge, so galactic magnetic fields alter their paths. It's essentially impossible to trace cosmic rays back to their source.

A galaxy with a lot of massive star formation should correspond to a larger number of supernovae — massive stars die in such bright blasts. These star-forming galaxies should therefore produce more cosmic rays, and gamma rays, than a normal galaxy like our Milky Way.

Scientists believe cosmic rays bounce back and forth in a supernova remnant's magnetic field until they've reached energies high enough to escape. As the cosmic-ray particles interact with surrounding interstellar gas, they create gamma rays. Like other photons, gamma rays are charge neutral, so magnetic fields do not affect their movement.

While Fermi can detect the gamma rays directly (the satellite is above the atmosphere), VERITAS must rely on a natural tool: As gamma rays hit our atmosphere, they initiate a shower of particles and a flash of blue light. VERITAS researchers look for that flash, called Cerenkov radiation, to indicate an incoming gamma ray.

In June, a group with the European Southern Observatory reported its finding that hints of supernovae as accelerators. They measured the temperature behind a shock wave associated with supernova remnant RCW 86 and found that it's cooler than expected. The missing energy could have gone toward accelerating the particles.

^ **As part of** the International Year of Astronomy, the Great Observatories (Hubble, Spitzer, and Chandra) combined observations to create this multi-wavelength view of M101. NASA/ESA/CXC/SSC/STScI

< **In 2009,** the world honored 400 years of astronomy with a year-long celebration. IYA2009

8 Year of astronomy celebrated by nations worldwide

This past year was a big one for getting the public interested in astronomy. At the center of it all was the International Year of Astronomy (IYA2009), essentially a yearlong birthday celebration of the telescope.

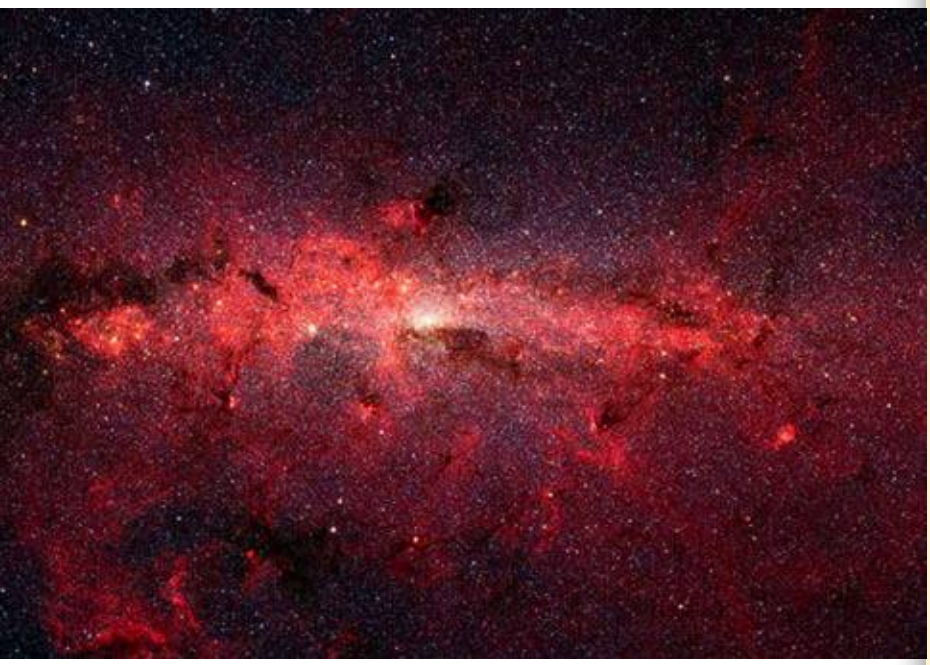
Four hundred years earlier, in 1609, Galileo Galilei pointed his spyglass toward the heavens and saw the Milky Way band in a way never before viewed.

The IYA2009 honored "400 years of astronomy" by creating 12 cornerstone projects, and astronomers (both professional and amateur) planned hundreds of other events to bring the sky to the public. The largest project was "100 Hours of Astronomy," which incorporated some 1,500 events in more than 130 countries. Mike Simmons, 100 Hours of Astronomy co-chair, says, "Astronomers are known for their enthusiasm and love of sharing knowledge, which are the main ingredients of 100 Hours of Astronomy."

From April 2 to 5, more than 2 million people around the world viewed the skies. And for 24 of those 100 hours, research institutions took web viewers into some of the most advanced research observatories with "Around the World in 80 Telescopes."

Throughout the year, IYA2009 organized smaller exhibits in a cornerstone project called "From Earth to the Universe." Some 250 locations — airports, parks, and city centers — across the globe showcased gorgeous images of astronomical objects.

The IYA2009 vision was to encourage people to rediscover their place in the universe. It was so successful, the IAU launched a decade-long program for global development of astronomy.



Our galaxy's core is a violent place, yet astronomers have found several baby stars still within their gas and dust cocoons in the region. NASA/JPL-Caltech/S. Stolovy (Spitzer Science Center/Caltech)

7 Milky Way's violent center hosts baby stars

The Milky Way's center is a chaotic place with severe turbulence and intense radiation. Because stars need time and an environment without extreme gravitational tidal forces to form, the galactic center isn't exactly conducive to stellar formation. Or is it? In 2009, two separate teams of astronomers using different detection methods announced that they had each discovered distinct baby stars near the Milky Way's core.

Elizabeth Humphreys of Harvard and colleagues announced January 6 that they had found clear signs of two protostars 7 and 10 light-years from the galactic center, respectively. Humphreys' group looked for water masers near the Milky Way's black hole. Masers are the microwave equivalent of lasers, and they often serve as signposts of protostars still embedded in their natal cocoons. After taking other factors into account, the team found two water-maser sites associated with likely protostars. One of those stars sits at the edge of a gas and dust cloud orbiting the central black hole.

This finding points toward stars forming near the galactic core. For the gas and dust clouds to form stars, however, the clouds must be substantially denser for their gravity to overcome the intense gravitational forces at the galactic center.

A different group, led by Deokkeun An of the California Institute of Technology, announced June 10 that it had found the spectral fingerprints of three protostars in the central region. These stars are also less than 1 million years old and are still in their natal clouds. Instead of using water masers, this team used the Spitzer Space Telescope's infrared eye to pierce through the dust and identify 107 young star candidates. The scientists then studied each candidate object's spectrum to detect the imprints of certain molecules. These spectra tell the astronomers which objects are young stars and which aren't.

These newborn stars lie farther out than those discovered by the Humphreys team. However, at 300 light-years, these protostars are still well within the galactic center and close enough to the black hole to be affected.

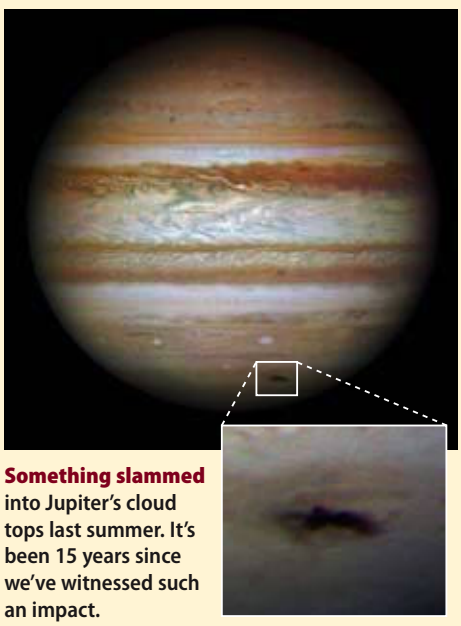
6 Space object bruises Jupiter

On July 19, amateur astronomer Anthony Wesley was observing Jupiter from his home observatory outside Murrumbateman, Australia. He spotted a dark mark almost the size of Earth on the gas giant's south polar region. Shortly thereafter, he alerted the astronomical community, and telescopes all over the world shifted their gaze on Jupiter's new scar. Something had crashed into the planet and exploded in its cloud tops to create the black spot.

During the next few weeks, scientists studied the mark to try to determine what caused it. They observed the spot in wavelengths other than visible light. They split up its light to detect the fingerprints of different chemicals. They also looked at the turbulence pattern in Jupiter's clouds. Because no one had viewed the impacting mass, astronomers use this information to determine the object's trajectory and what it may have been.

They determined that the impactor was several hundred yards across and was likely either a comet or an asteroid. The crash packed a lot of punch — the equivalent of millions of tons of TNT. Fortunately, Jupiter's gravitational influence pulls these types of objects toward the gas giant.

The July event wasn't the first such Jupiter collision that astronomers have witnessed. Almost exactly 15 years earlier, Comet Shoemaker-Levy 9 fragmented and crashed into the gas giant.



NASA/ESA/M. Wong (STScI, Baltimore)/H. B. Hammel (Space Science Institute, Boulder, Colorado)/and the Jupiter Impact Team

Something slammed into Jupiter's cloud tops last summer. It's been 15 years since we've witnessed such an impact.

5 Fermi Space Telescope boasts big haul

A few months after the Fermi Gamma-ray Space Telescope launched in summer 2008, astronomers began announcing lots of gamma-ray goodies. And its 1-year data release increased the number of finds. From a detailed map of the gamma-ray sky to a whole slew of once-thought-rare objects, Fermi has shown us a plethora of high-energy objects in our sky — more than 1,000 of them.

Fermi's Large Area Telescope (LAT) is some 30 times as sensitive as its predecessor. The LAT scans the entire sky in 3 hours, which lets scientists see rapidly changing sources.

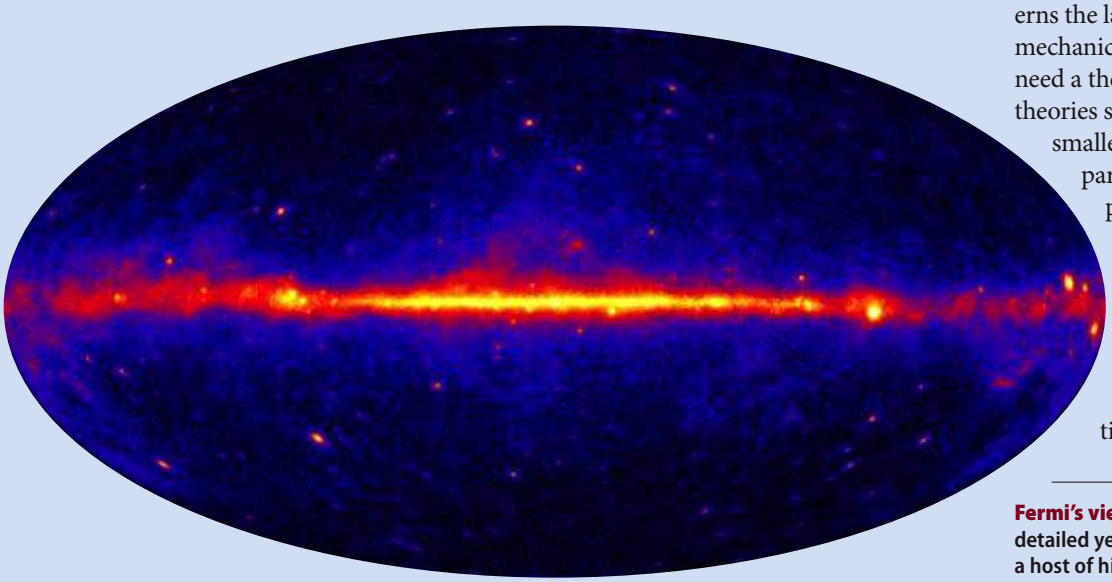
One of these sources is a pulsar — a rotating neutron star that emits energy jets out of its poles. Astronomers knew of hundreds of these objects that emit radio waves, but only seven that emit just gamma rays. They now know of more than 50, nearly half of which Fermi discovered and some that aren't visible in light other than gamma rays.

But Fermi's largest haul has been blazars — galaxies with active central supermassive black holes that spew jets directly toward us. The LAT has found more than 600 blazars.

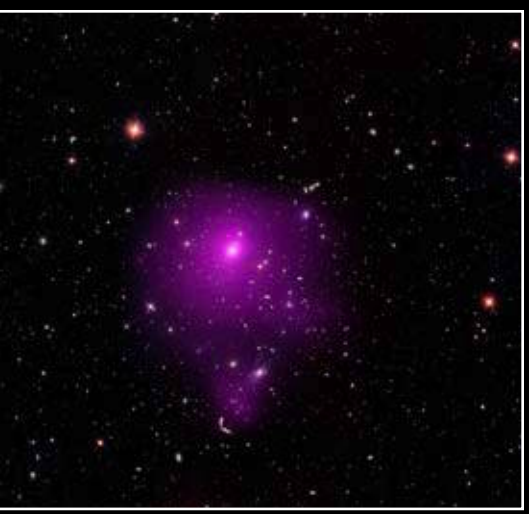
In addition, Fermi's gamma-ray burst monitor (GBM) observed 317 GRBs — extreme cosmic blasts — by October. Of those GRBs, the LAT discovered energies billions of times greater than visible light from 12 of them. Three of these 12 GRBs have set records. And Fermi scientists used one of those bursts to constrain physics theories.

For decades, physicists have struggled to find a way to unify gravity (what governs the largest scales) with quantum mechanics (subatomic scales). Scientists need a theory of quantum gravity. Some theories say space-time is foamy on scales smaller than particles. At these scales, particles interact with the foam and produce unexpected behaviors.

A photon has a wavelength that depends on its energy. So a high-energy photon (gamma ray) has a smaller wavelength than visible light. When you approach energies billions of times greater than visible light, the



Fermi's view of the gamma-ray sky is the most detailed yet. The space telescope has discovered a host of high-energy objects and promises many more. NASA/DOE/Fermi LAT Collaboration



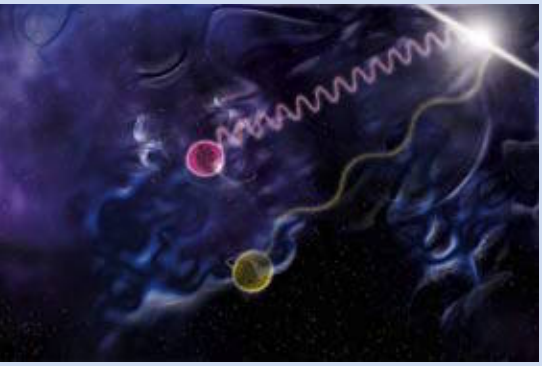
X-ray (NASA/CXC/SAO/A. Vikhlinin et al.); Optical (SDSS)

Abell 85 is one of the 86 galaxy clusters Chandra X-ray Observatory astronomers studied. Roughly half of these clusters are about 5 billion light-years away, while the others are within some 1 billion light-years of us.

4 Dark energy find helps constrain its properties

The past year gave us another confirmation of dark energy's existence. But this method didn't look for supernovae, the exploding stars that first showed astronomers that cosmic expansion is speeding up. Instead, researchers studied how the growth of galaxy clusters — some of the universe's largest structures — changes over cosmic time. They found that structure growth has slowed in the past 5 billion years. Astronomers believe that around 5 billion years ago dark energy "kicked in." "This is an unmistakable signature of dark energy," says Alexey Vikhlinin of the Smithsonian Astrophysical Observatory, who led the survey.

Scientists discovered in 1998 that something is making the universe expand at a faster rate. They called this something "dark energy." Previous dark energy studies (such as supernovae observations, which scientists used 12 years ago) have relied on how the universe's expansion varies with distance. But in this study, published February 10 in *The Astrophysical Journal*, the observations didn't depend on distance, thus providing an independent measure of dark energy.



NASA/Sonoma State University/Aurore Simonnet

Two photons from GRB 090510 have energies differing by about a million times. The higher-energy photon (purple in this illustration) arrived less than 1 second after the lower-energy photon (shown as green).

wavelength gets so small that, in theory, it could interact with space-time's foaminess. Then the high-energy photon should feel the foamy "bumps" in the same way a go-cart feels the rocks on a gravel road but a monster truck doesn't. Some quantum theories say these "bumps" should slow the high-energy photon.

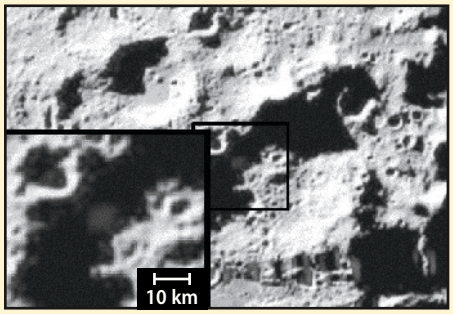
Fermi measured two photons from GRB 090510, about 7 billion light-years away; one was a million times more energetic than the other. Both photons arrived at the detector less than 1 second apart, so the more energetic photon didn't slow over 7 billion light-years. This finding knocks out a few quantum theories and helps physicists constrain their models.

Scientists used data from the Chandra and ROSAT X-ray observatories to study 86 galaxy clusters at varying cosmic times. They measured both the masses of those clusters and the number of clusters 5 billion light-years away and others less than a billion light-years from us. The astronomers had assumed that over time dark energy's repulsive effect would slow the growth of galaxy clusters by counteracting gravity's pull. That's what they found.

Astronomers now have two independent confirmations of dark energy's existence. And in science, when two different methods come to the same conclusion, you can count out sources of experimental error. Not just that, but astronomers can combine the methods to constrain dark energy's properties.

3 NASA finds water, a crucial resource, on the Moon

June 18 marked NASA's launch of two lunar spacecraft: the Lunar Reconnaissance Orbiter (LRO) and the Lunar CRater Observing and Sensing Satellite (LCROSS). It's been about 10 years since the United States sent a satellite to the Moon, so the launch was a welcome sight. And even more welcome was what LCROSS found: water.



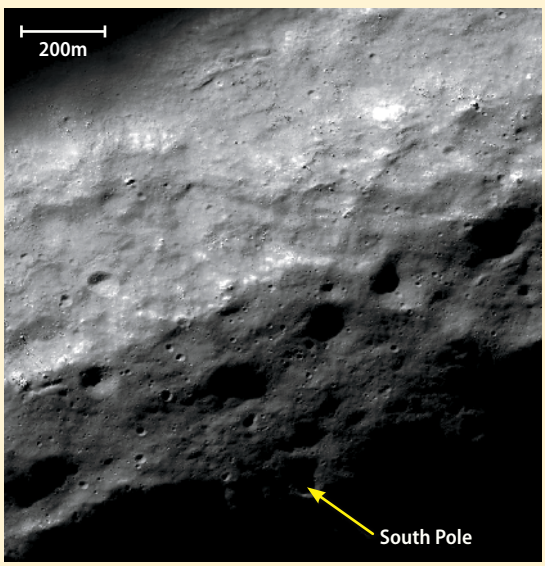
The LCROSS camera imaged the ejecta plume 20 seconds after the Centaur rocket impacted the Moon. NASA

Shortly after launch, the two craft separated to take different paths to the Moon. LCROSS was a 2-part mission consisting of the Centaur rocket impactor and a probe spacecraft, which impacted the Moon after capturing each stage of Centaur's impact. The Centaur rocket first slammed into the Moon's Cabeus Crater, a permanently shadowed region about 62 miles (100 km) from the south pole, October 9.

While the impact flash wasn't as bright as expected, Anthony Colaprete, LCROSS principal investigator and project scientist, says team members are ecstatic. "Multiple lines of evidence show water was present" in the plume, he adds. In fact, they detected at least 24 gallons of water mixed in with the frozen lunar dust grains.

LRO's seven instruments have focused on mapping the surface and looking for the spectral signature of water at the Moon's surface. The Lunar Exploration Neutron Detector confirmed there is hydrogen (a signpost of water) near the south polar region. Scientists also have found evidence of hydrogen in equatorial regions, although it's less abundant. This information combined with LCROSS's water detection proves that our Moon does harbor water, which will be useful for future manned missions.

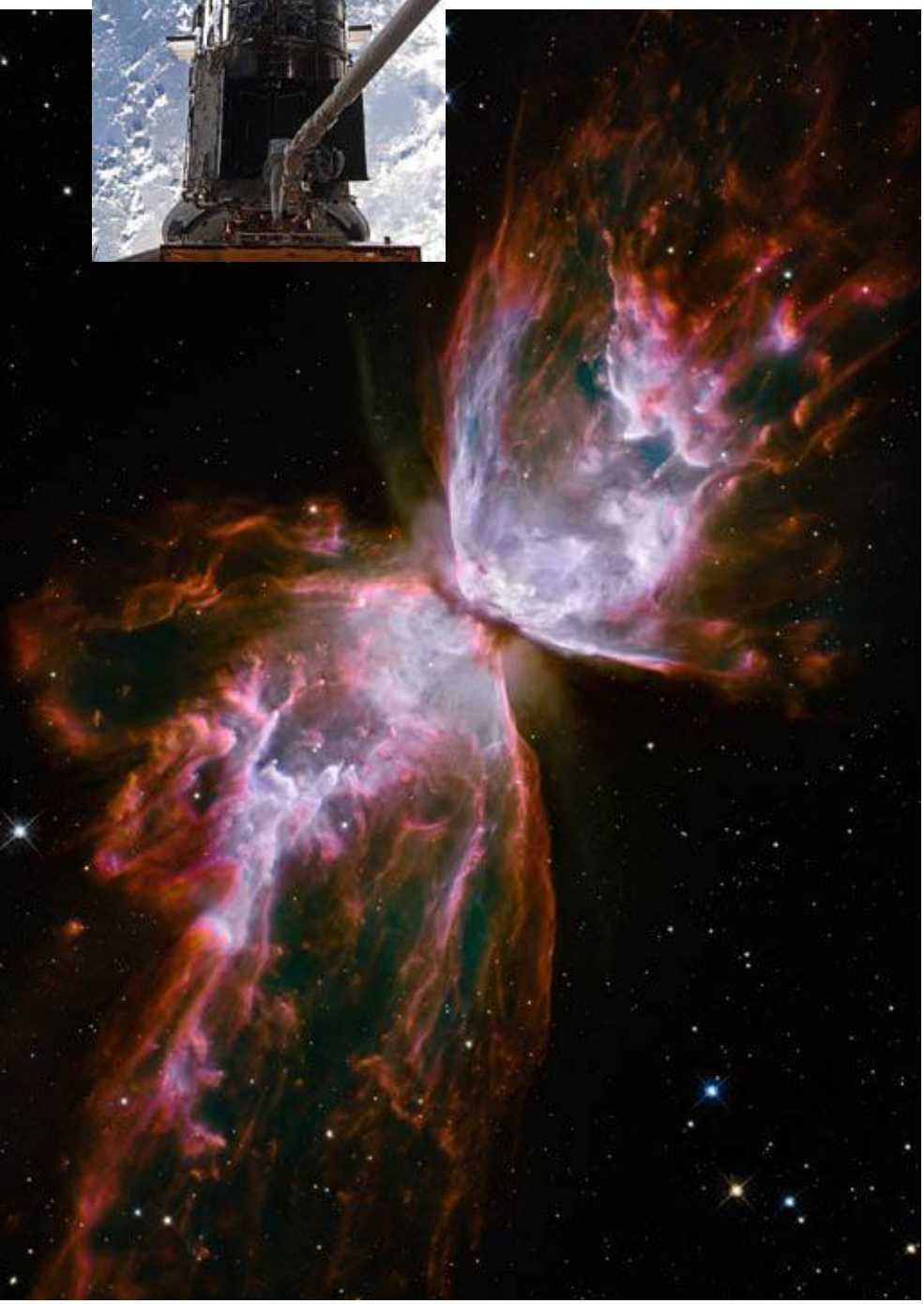
The Diviner instrument is measuring temperature variations across the Moon. It already has shown that the daytime temperature in permanently shadowed regions doesn't get above 35 kelvins, making it likely the coldest place in the solar system.



The lunar south pole emerges from the shadows as the Moon enters its summer months. This LRO camera image is more than 1.2 miles wide (2 km). NASA/GSFC/Arizona State University

Other instruments are focusing on mapping techniques. Within 30 days of starting science operations, the Lunar Orbiter Laser Altimeter had mapped most of the south pole's terrain.

In 6 days, astronauts completed five spacewalks to upgrade the Hubble Space Telescope. Here, mission specialist Michael Good rides the shuttle's robotic arm to be in position to continue working on Hubble. NASA



2 Hubble gets new lease on life

Astronauts gave the Hubble Space Telescope a much-needed upgrade in 2009. It had been 7 years since Hubble's last repair mission, and the telescope showed it. Two of its four science instruments had suffered power failures, Hubble was down to three of six gyroscopes (it needs two to point accurately), and the main data-handling unit (which provided electronics to send data between Earth and Hubble) had failed. So on May 11, space shuttle *Atlantis* blasted off to provide some extensive repairs.

After a 2-day flight, *Atlantis* caught up with Hubble and used the shuttle's robotic arm to snatch the satellite and lock it in *Atlantis*' cargo bay. Five spacewalks to repair Hubble followed over the next 6 days. While there were a few glitches, all key upgrades went well. *Atlantis* released the satellite May 19, and scientists and engineers on Earth's surface got to work.

What followed was more than 3 months of verification and calibration. In addition to setting up the two new instruments — the Wide Field Camera 3 (WFC3) and the Cosmic Origins Spectrograph (COS) — scientists had to get the repaired instruments up and running. And then there was the business of calibrating all six replaced gyroscopes to make sure Hubble could point accurately.

The mission was a resounding success. Hubble astronomers released a slew of new images and other data September 9. They chose objects to show off just what the upgraded Hubble can do. It looks like we can expect a lot more science from the telescope.

The refurbished Hubble Space Telescope captured NGC 6302 July 27. This is a planetary nebula, formed after a Sun-like star went through its death throes. NASA/ESA/The Hubble SM4 ERO Team

Read space stories 11 through 15 at www.Astronomy.com/toc.

Stories to watch in 2010

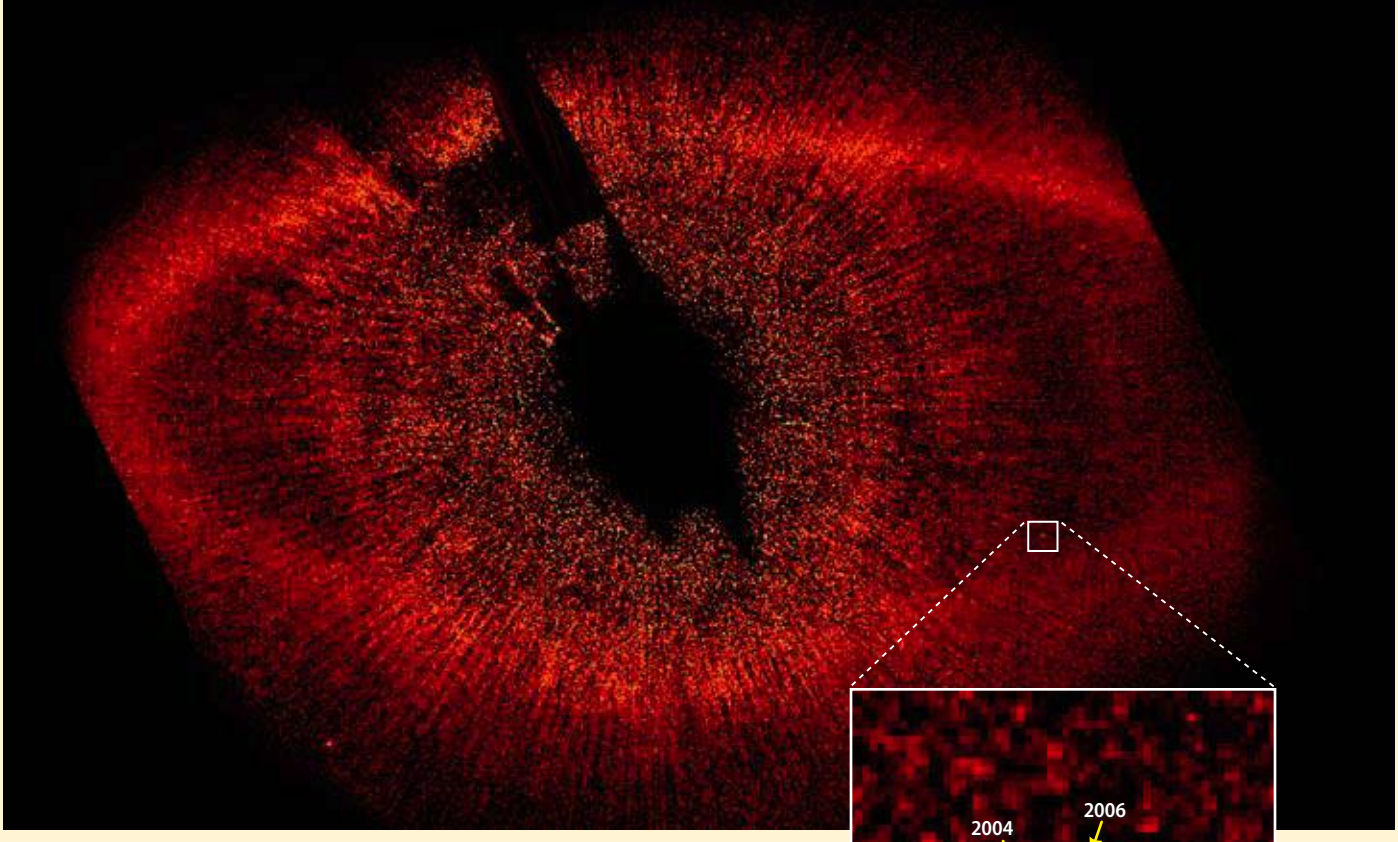
NASA's Kepler mission should begin returning data about not just exoplanets, but the stars themselves.

Herschel's sharp infrared eye is studying uncharted radiation regions. We should see results in 2010.

LHC, the Large Hadron Collider accelerator, was scheduled to get back online as 2009 became 2010. Its extreme energies should produce particles never seen before.

Comet 103P/Hartley should be a bright, naked-eye comet in October. And the Deep Impact extension mission will fly by the comet around that time.

Hubble's upgraded science operations will provide new details about celestial objects and probe bright phenomena in the distant universe.



Exoplanet Fomalhaut b (lower right) likely shapes and maintains the dusty ring around Fomalhaut. The zoom-in image shows the same planet 21 months apart.

NASA/ESA/P. Kalas, J. Graham, E. Chiang, E. Kite (University of California, Berkeley)/M. Clampin (NASA's Goddard Space Flight Center)/M. Fitzgerald (Lawrence Livermore National Laboratory)/K. Stapelfeldt, J. Krist (NASA's Jet Propulsion Laboratory)

1 A big year for extrasolar worlds

The search for extrasolar planets has come a long way since scientists discovered the first one in 1991. Late 2008 and 2009 marked a number of big exoplanet announcements: Astronomers directly imaged two exoplanet systems, found the lightest exoplanet yet orbiting a normal star, confirmed the first rocky exoplanet, and detected a jackpot 32 extrasolar worlds in one study.

In November 2008, two separate teams of astronomers announced that they had imaged extrasolar planets.

One group used the Hubble Space Telescope to image Fomalhaut twice (about 21 months apart) to ensure that the planet (Fomalhaut b) orbits the star. The group determined that it orbits about 4 times the Sun-Neptune distance from the star. This system sits roughly 25 light-years away in the southern constellation Piscis Austrinus. Theoretical models put the planet's mass at less than 3 times Jupiter's.

The Keck and Gemini telescopes captured the first images of planetary family HR 8799 and its three planets. W.M. Keck Observatory

Another group imaged in infrared radiation a system of three planets around HR 8799, a star 130 light-years away in Pegasus. The three gas giant exoplanets orbit at roughly 24, 38, and 68 astronomical units (AU, the Earth-Sun distance), and each is several times Jupiter's mass. Astronomers say this extrasolar system looks like a scaled-up version of our planetary system. With three gas giants in the outer region, it leaves room for other planets closer in.

This past year wasn't only about imaging exoplanets — astronomers detected an exoworld with an estimated mass of just 1.9 Earth masses. The team used the High Accuracy Radial velocity Planet Searcher (HARPS) spectrograph to detect small changes in the star's movement, indicating a planet pulling on the star. The team announced its finding April 21. While this planet, Gliese 581 e, may be rocky, it orbits too close to its host star (about 0.22 AU) to have surface water.

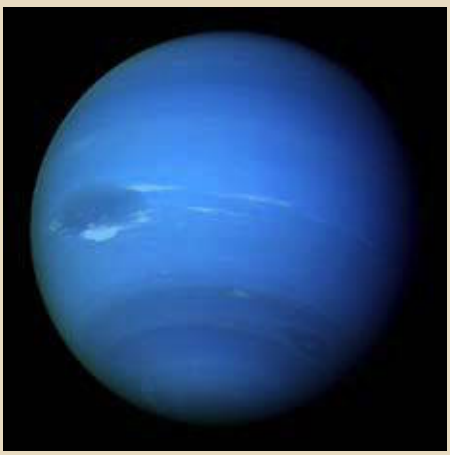
And in September astronomers using the HARPS spectrograph announced that it had confirmed exoplanet CoRoT-7b's mass. This information, combined with the planet's diameter (about 1.7 times Earth's), gives it a density almost identical to Earth's. This marks the first evidence for a rocky planet outside our solar system. But it's not earthlike. Instead, it's so close to its star (about 0.017 AU) that it may have a lava surface.

Then in October the HARPS European collaboration helped close out the big exoplanet year. It reported a huge exoplanet haul: 32 in one study. The exoplanet count has now jumped past 400.

Astronomers seem to be inching ever closer to the significant find of an earthlike planet. And the Kepler mission, which launched March 6 to search for a variety of extrasolar planet systems, has a chance of achieving that goal.

Liz Kruesi *is an* Astronomy *associate editor.*

How astronomers probe weather



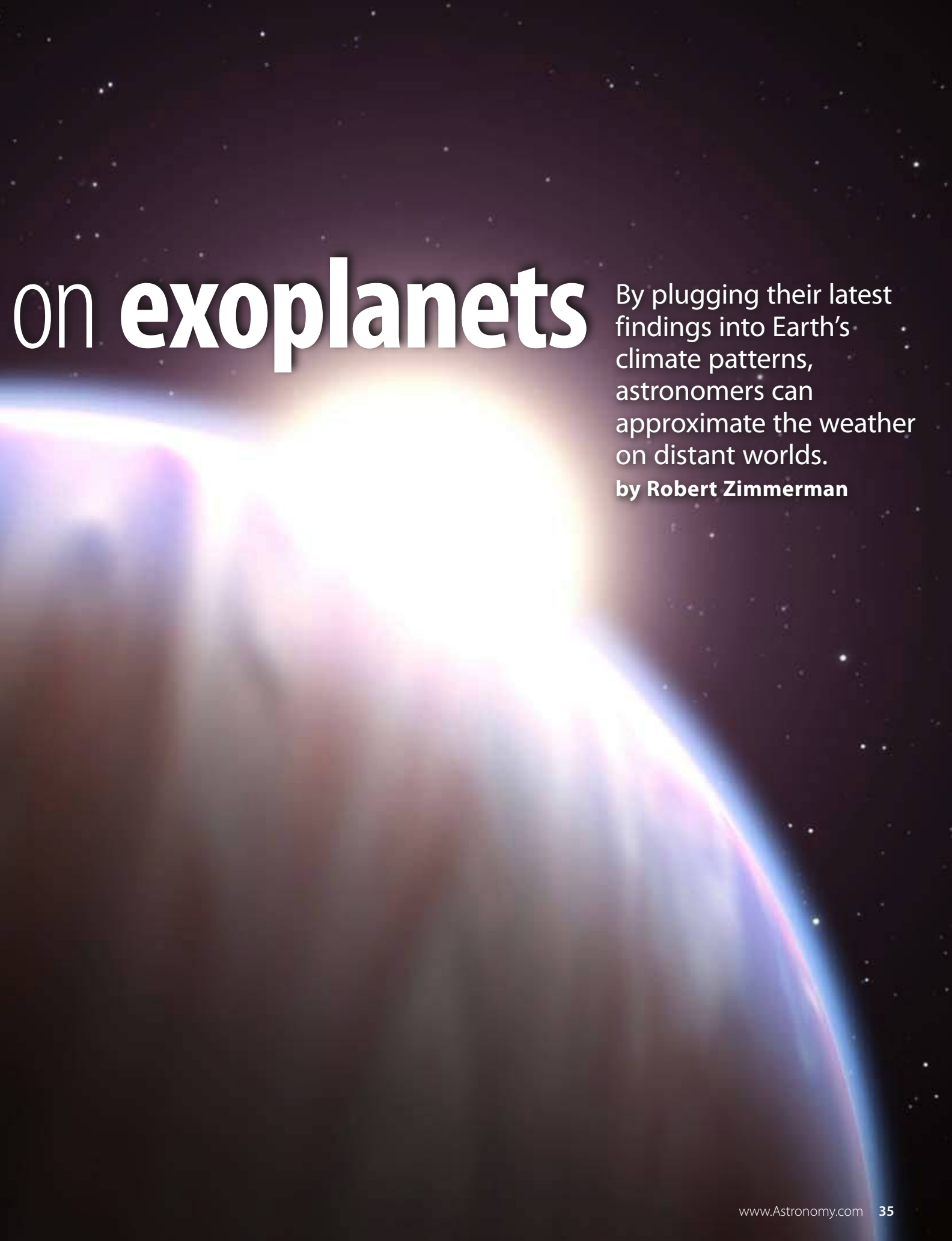
Neptune, the most distant planet in our solar system, was once just as inscrutable as the farthest exoplanet. Voyager 2/ NASA/JPL

When our ancestors first looked at and wondered about the night sky, they must have felt overwhelmed. So many stars, all so far away — how could we ever hope to learn what they might be like? Over the centuries, though, science has steadily increased our knowledge of the stars and planets, while at the same time presenting more distant, and equally mysterious, objects to marvel over.

At first we grouped the stars into constellations and discovered the solar system's planets. Fascinating in their march across the sky, we devised theories about their natures, then their orbits, and eventually even their atmospheres and terrains. Now our solar system is as familiar to us as our local neighborhood, and astronomers are starting to train their focus on the next big planetary mysteries: worlds outside our solar system.

Extrasolar planets are particularly difficult for astronomers to study. They are located vastly far away and are usually unobservable directly. Any data

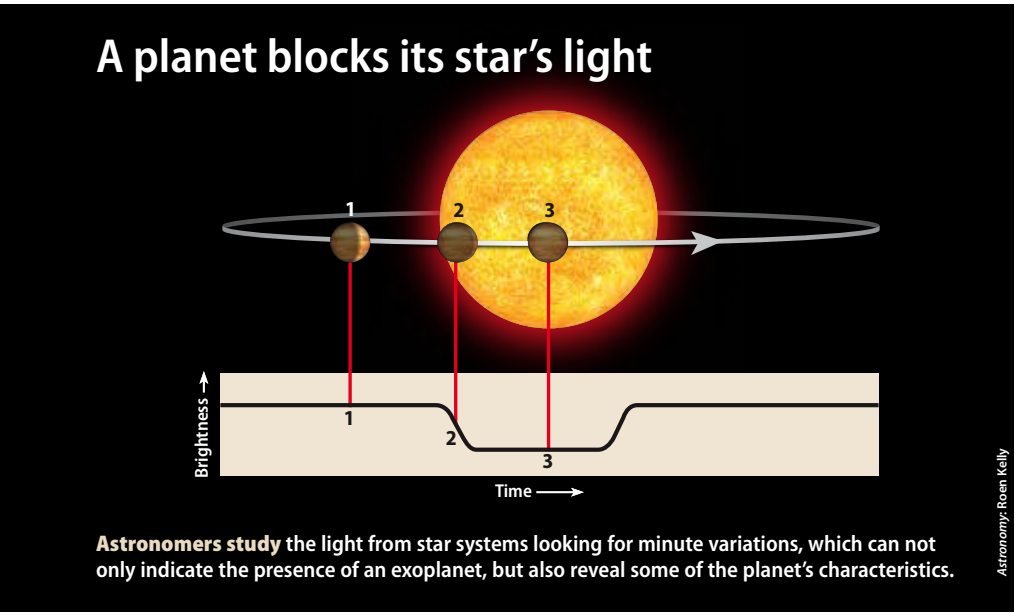
Exoplanet HD 189733b, depicted here with its host star HD 189733 in the constellation Vulpecula the Fox, is the first exoplanet with a successfully mapped surface. NASA/ESA/G. Bacon (STScI)



on **exoplanets**

By plugging their latest findings into Earth's climate patterns, astronomers can approximate the weather on distant worlds.

by Robert Zimmerman



Astronomers study the light from star systems looking for minute variations, which can not only indicate the presence of an exoplanet, but also reveal some of the planet's characteristics.

scientists discover come from the absolute limits of modern technology, making it remarkably sketchy.

And yet, in the last half dozen or so years, astronomers have been gathering copious amounts of information about those alien worlds. They now can even map out the atmosphere and predict the weather on a handful of planets.

We're witnessing the birth of extrasolar meteorology. In the future, not only will astronomers be able to study extrasolar planetary weather and climate, but they also will use these techniques to identify atmospheres on earthlike planets. Thus, we are getting close to discovering the first extrasolar planets where life as we know it could very well exist. As Adam Showman, a planetary scientist at the University of Arizona, notes, "I think we're seeing the cusp of a new era."

Upstaging the stars

Scientists discovered most of the more than 400 exoplanets currently known by measuring the faint wobble in a star's motion, the result of an orbiting planet's weak gravitational influence. Though reliable for detection, this method tells scientists little about the planet itself, other than minor details about its orbit and mass.

Certain extrasolar planets, however, provide astronomers with far better data. The orbits of these special planets happen to align with our line of sight, so we can see the planet cross in front of and behind its star.

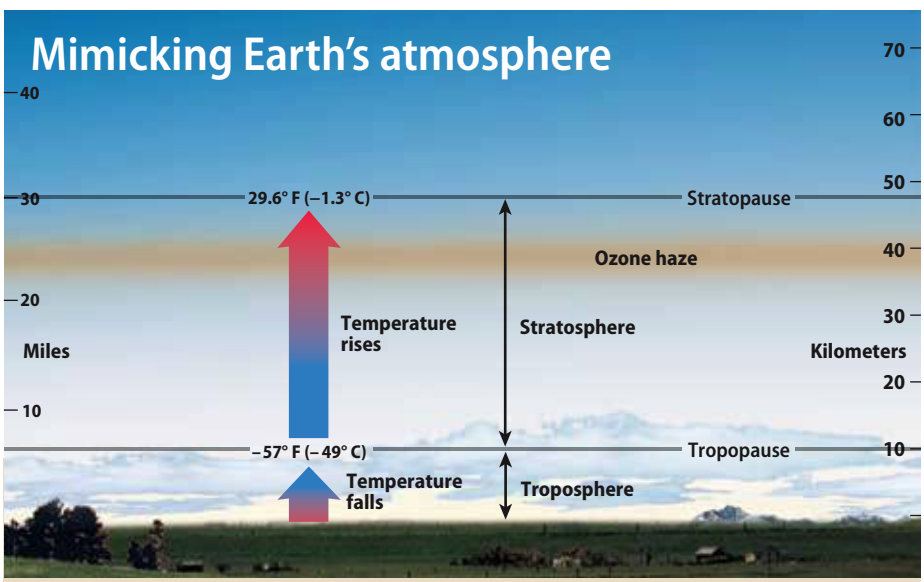
When the planet passes behind the star, only the star's light reaches us on Earth. By analyzing the spectrum of that light, astronomers obtain a baseline of data, showing them the star's chemical makeup. Then, when the planet emerges from behind the star, any changes in the system's spectrum can tell astronomers something about the planet. Furthermore, when the planet moves in front of the star — or transits, to use the astronomical term — the star's light travels through the planet's atmosphere before it reaches us. Any further changes to its light spectrum reveal details about the planet's atmosphere.

Amazingly, despite such a tiny amount of data, scientists have been able to cull an enormous amount of information about those distant planets.

A starring role

So far, scientists have discovered about five dozen transiting extrasolar planets, with the biggest news splash belonging to HD 80606b. This planet, with a mass about 4 times that of Jupiter and located some 190 light-years away, has the most eccentric orbit of any known exoplanet. At the orbit's farthest point, HD 80606b is 80 million miles (125 million kilometers) from its star, a distance slightly greater than Venus' from our Sun. But every 111 days or so, HD 80606b drops inward, whipping past its sun at a distance of barely more than 3 million miles (5 million km).

Careful analysis of this orbit suggested it might be a transiting planet, oriented to us so its star could eclipse and hide it. In November 2008, astronomers used the Spitzer Space Telescope to monitor the star's infrared brightness, hoping to spot such an eclipse. To their joy, they succeeded. The data not only tracked the planet's orbit as it moved behind the star,



Earth's atmosphere gets steadily cooler with altitude until a certain point, called the tropopause, where the opposite begins and temperature increases with height. Scientists have discovered a similar phenomenon on some exoplanets, perhaps the result of "hazes" in their atmospheres, similar to Earth's ozone layer. *Astronomy*: Roen Kelly

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Robert Zimmerman *is the author of* The Universe In a Mirror: The Saga of the Hubble Space Telescope and the Visionaries Who Built It *(Princeton University Press, 2008).*

but it also showed that at closest approach temperatures in the planet's upper atmosphere rose from about 1000° Fahrenheit (540° Celsius) to more than 2200° F (1200° C). What's more, this temperature increase took place in only 6 hours.

For the first time, astronomers had seen a change in the weather on a planet orbiting another star.

After these November 2008 observations, Gregory Laughlin of the University of California at Santa Cruz further analyzed the orbit. He predicted that the planet might move across the face of its parent star when it reached the other end of its orbit February 14, 2009.

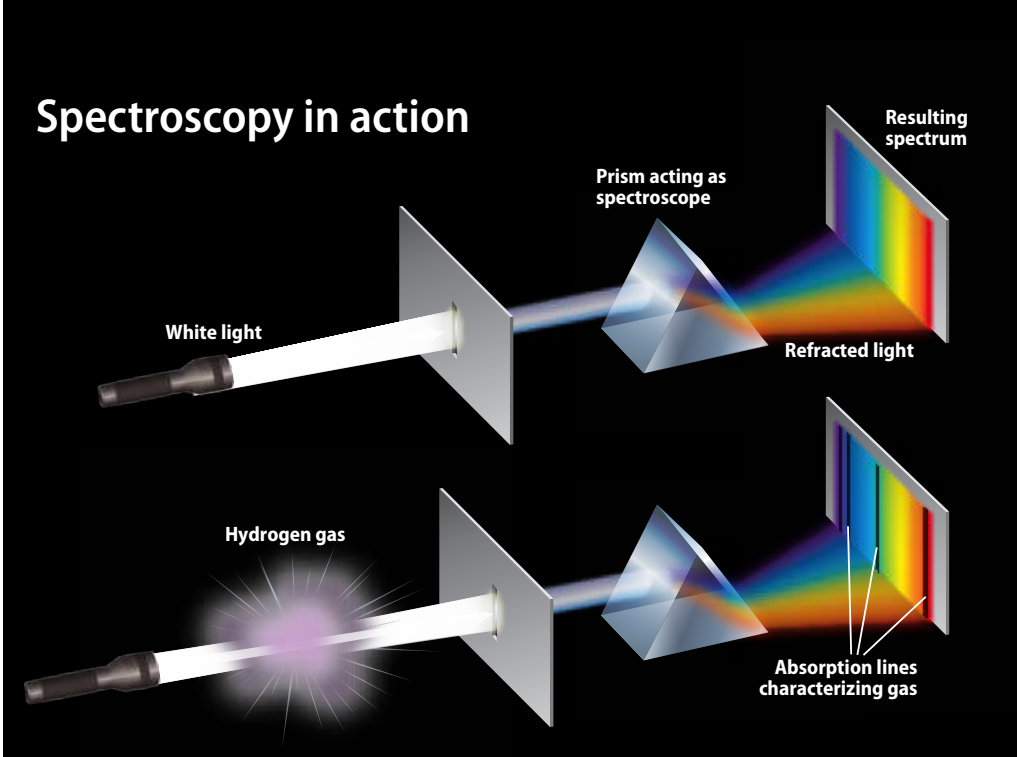
"Greg made a movie poster," remembers Drake Deming, planetary systems laboratory chief at NASA's Goddard Space Flight Center. It read: "HD 80606b transiting this winter? Ephemeris: Feb. 14th, 2009. Watch the skies." By uploading this poster on his weblog, www.oklo.org, Laughlin acted to encourage as many observations of the event as possible.

Thus, not only did professional scientists observe the February transit, but so did a team of undergraduate students at University College London. As Laughlin later wrote on his weblog, "It's certainly been a long time since an observational astronomical discovery of this magnitude has [been] made from within the London city limits!"

With this data, astronomers confirmed the planet's extreme atmosphere and also learned that the planet's orbit and the star's rotation do not align, as is typically the case. In other words, the planet's orbit (and thus our line of sight to it) must be highly inclined to the star's equatorial plane.

It turns out HD 80606b's violently fluctuating weather is just one intriguing aspect of this transiting exoplanet. Because of its eccentric and highly inclined orbit, the planet doesn't mimic the behavior of a normal planetary solar system like our own as much as it does that of a binary star system. In fact, the planet is in a binary system; the system's companion star lies about 100 billion miles (160 billion km) from the main star. Some astronomers theorize that it is the presence of the system's second star that elongates and tilts HD 80606b's orbit.

But for scientists, the weather on "hot Jupiter" type transiting planets fascinates even more. The name comes from the incredibly close distances at which these Jupiter-mass planets orbit their stars every few days — generally less than 5 million miles (8 million km).



When analyzing a star's light, scientists look for spectral "fingerprints," a pattern of colors different for every individual element, to determine that star's composition. This process, called spectroscopy, is also useful for determining the chemical makeup of exoplanets and their atmospheres when they pass in front of their stars' light. *Astronomy:* Roen Kelly

These gas giants, which make up the majority of known extrasolar planets, were an unexpected phenomenon when first discovered in the 1990s. No one had ever imagined such a giant planet could even exist that close to its star, much less have an active atmosphere. Even today, no one really understands what conditions are like on these remarkably large and hot planets.

Forget the sunscreen

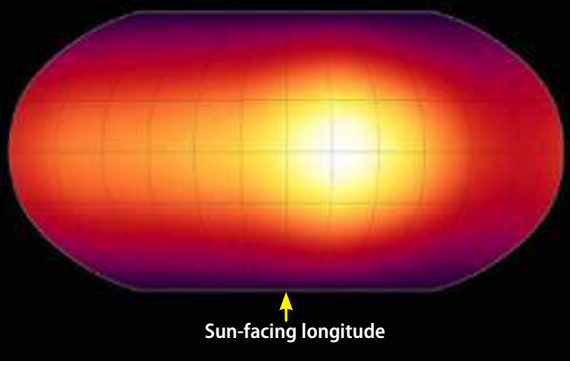
Hot Jupiter HD 209458b was the first exoplanet where astronomers detected specific chemicals in the atmosphere. Located 150 light-years away and slightly bigger than Jupiter, this exoplanet transits its star every 3.5 days at a distance of 4.2 million miles (6.7 million km), allowing astronomers to study it in surprisingly good detail.

In 2001, astronomers used the Hubble Space Telescope to discover sodium in the planet's atmosphere. Since then, water, methane, and carbon dioxide have joined the sodium, as well as what appears to be hydrogen wind blowing away from the planet. Because of HD 209458b's close proximity to its star, the heat from the star causes the upper layers of the planet's atmosphere to expand, so hydrogen evaporates away as wind. More amazingly, astronomers have crudely mapped what they think is the planet's basic atmospheric structure. For example, the data suggest that HD 209458b's atmosphere has a cooler layer capped by a warmer upper layer.

This kind of temperature inversion is also a basic feature of Earth's atmosphere. On Earth, the troposphere forms the atmosphere's lowest layer, from the ground to about 6 miles (10 km) elevation. In this layer, as you travel upward, the temperature goes down, dropping about 120° F (50° C) total. Above this altitude is the stratosphere, from about 6 to 30 miles (10 to 50 km). Here, the temperature instead rises slowly as you go up, about 80° F (25° C) total. The temperature increase results from the ozone layer in the stratosphere, which absorbs the Sun's ultraviolet radiation and thus its heat.

In the case of HD 209458b, the temperature difference between the two atmospheric layers is gigantic: about

Mapping an exoplanet



The first thermal map of any exoplanet depicts the temperatures on HD 189733b, with hotter temperatures appearing brighter. The planet is tidally locked, meaning the same side always faces its star, with the central longitude here directly facing its sun. The map shows that the hottest point is not the middle of the day side, but a spot to the east. NASA/JPL-Caltech/H. Knutson (Harvard-Smithsonian CfA)

1900° F (1000° C) in the lower layer, and 3200° F (1750° C) or more in the upper. It is this extreme heat in the upper atmosphere that probably fuels the planet's escaping hydrogen wind. Other data have shown evidence of hazes in this upper layer, suggesting that some chemical in the upper atmosphere may absorb sunlight and warm the upper atmosphere, much like ozone does in Earth's stratosphere.

Unfortunately, astronomers have no idea what the chemical or chemicals might be. At first they theorized that the hazes consisted of molecules of either titanium oxide or vanadium oxide, both of which are excellent light absorbers. (A variation of titanium oxide is the basic ingredient in most sunscreens.) But over time, this theory couldn't hold up.

Whatever chemical is causing the temperature inversion must somehow remain in the upper atmosphere or become replenished, even though it absorbs energy from its star. Both titanium oxide and vanadium oxide, however, condense when they absorb light, thereby settling out of the atmosphere. Moreover, no one has come up with a mechanism that can recycle these molecules back into the upper atmosphere. "The bottom line is that we really don't know what is happening," explains Showman. "Anything that absorbs strongly in the visible [range of light] could cause the temperature inversion."

Partly cloudy?

HD 209458b is not the only exoplanet whose atmosphere astronomers have begun mapping out. Another one is HD 189733b, located some 63 light-years away. Weighing slightly more than Jupiter, it orbits its star every 2.2 days at a distance of less than 2.8 million miles (4.5 million km). Furthermore, unlike HD 209458b, which sits in a relatively empty part of the sky, HD 189733b lies in a crowded region. This gives ground observers many nearby stars with which they can calibrate their data.

As a result, astronomers have been able to detect evidence of water, carbon dioxide, carbon monoxide, sodium, and methane in HD 189733b's atmosphere. They have also detected hazes, though HD 189733b does not appear to have a temperature inversion like HD 209458b.

More intriguing, however, are the changes in HD 189733b's spectrum detected during different observations the past few years. Observations in 2006 showed no evidence of water in the planet's atmosphere, but data gained in 2007 did indicate the presence of water vapor. Such variations suggest that the upper atmosphere of the planet changed with time, a transformation that could have happened because the sky was initially clear, then cloudy or rainy.

Of course, a less exciting explanation might be that the first readings were not sensitive enough to pick up the water signature. "There was a fair amount of noise in the data," notes Adam Burrows of Princeton University. To know for sure requires more observations. "The next set of data, combined with what we've already obtained, should give us a pretty good view of the object, and perhaps tell us whether there is a credible case for variation."

Circulation patterns

With both HD 209458b and HD 189733b, however, the most intriguing results have come when the theorists plugged the available data into various existing atmospheric models for Earth and other solar system planets. "These [new] models have a heritage in the general circulation models that have been developed to follow Earth's weather," explains Burrows. By adapting these models to extrasolar hot Jupiters, scientists have produced amazingly detailed climate circulation patterns.

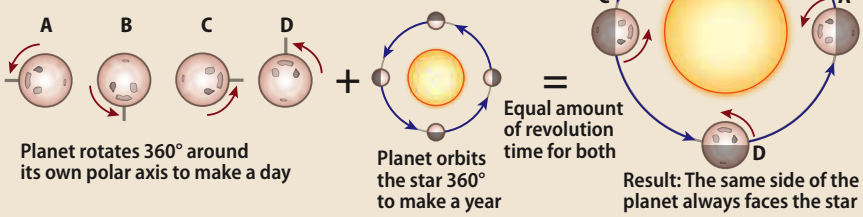
The scientists begin their models with one basic but reasonable assumption: Because a hot Jupiter orbits so close to its sun, tidal forces will have likely caused the planet's rotation period to equal its orbital period. This means one side always faces the star.

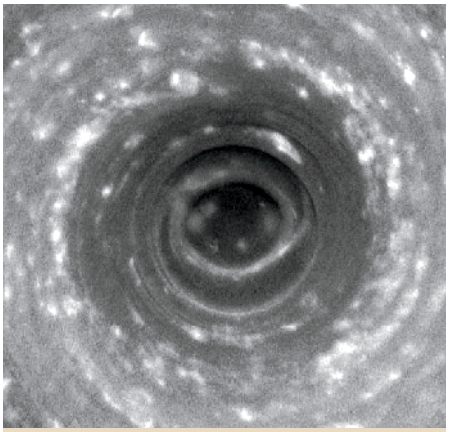
From this assumption follow many important details. For example, the subtle changes in the planet's "spectrum" (the light it gives off) as it moves from behind the star, then swings around across the star's limb, and then crosses in front of the star, mean astronomers see changing weather conditions at different times during the planet's yearlong day. "You can see the change in the flux as the night side rotates out of view and the day side rotates into view," explains Showman. On HD 189733b, for example, this changing flux indicates that the day side probably heats up to around 450° F (230° C) hotter than the night side.

By plugging this data into known climate models, the simulations also show

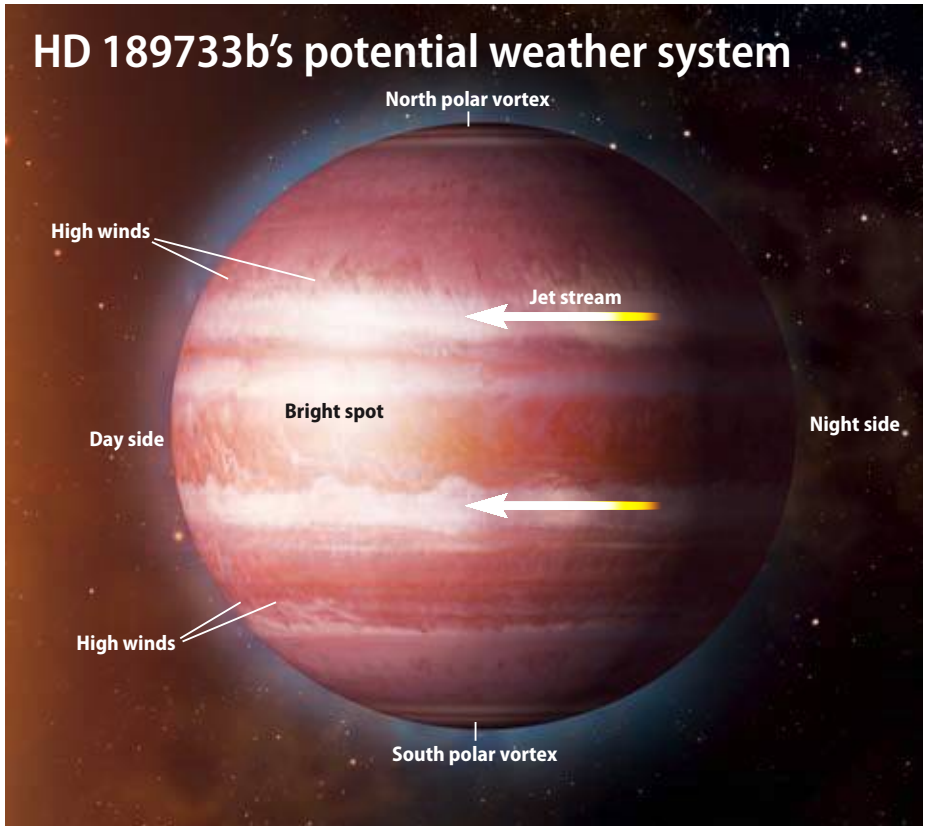
When a day equals a year

A tidally locked planet, where the same side always faces its star, still revolves around its own axis. *Astronomy*: Roen Kelly





Huge, long-lasting hurricanes called polar vortices, like this one on Saturn's south pole, may also exist on some exoplanets. NASA/JPL/SSI



Scientists can predict weather patterns on exoplanets by plugging their observations into known climate models. On HD 189733b, these models lead some astronomers to expect strong winds in high altitudes to transfer heat across the planet. They also think lower, broad jet streams encircle the planet at speeds faster than its rotation. *Astronomy*: Roen Kelly

a variety of specific circulation patterns at different altitudes. At the top of HD 189733b's atmosphere, high winds likely transfer the heat of the day side atmosphere to the night side. Lower in the atmosphere, this pattern disappears. Instead, three to five broad high-speed jet streams flow, circling the entire globe at speeds faster than the planet's rotation, ranging from approximately 1,100 to almost 8,000 mph (1,800 to 13,000 km/h). These jet streams resemble the bands that encircle Jupiter, but they are broader and far fewer in number.

In addition, the simulations show significant differences in weather conditions depending on latitude and longitude. They also suggest the warmest point on these hot Jupiters is not at noon of its yearlong day, but sometime later in the afternoon. Likewise, the planet's coolest spot is in the wee hours of the morning. Some models, though certainly not all, also indicate that these planets have gigantic and persistent hurricane-like vortices at their poles, similar to the poles on Venus, Jupiter, and Saturn.

The future meets the past

These descriptions of planetary atmospheres and weather systems might be based on the most recent scientific findings, but for those old enough to remember the days before spaceflight, the talk might seem strangely familiar. Before the first unmanned probes reached Mars or Venus in the 1960s, our knowledge of the planets was vague. Optical images from ground-based telescopes were too fuzzy to show much. Most of what astronomers knew came from studying each planet's albedo, the faint light that reflects off the world's atmosphere and surface. From the spectrum of that light, scientists could make rough estimates of the composition of a planet's atmosphere, weather, and environment.

Much like today's extrasolar planet research, the conclusions drawn from those faint data were sometimes good. Mostly, however, they were wrong or so lacking in detail that to draw any firm conclusions was difficult. For example, ground-based spectroscopy of Mars showed a very thin atmosphere, one-hundredth of Earth's, with a little water vapor and possibly some oxygen. Some scientists assumed that because so much of Earth's atmosphere is nitrogen, Mars' atmosphere must also have some. Wrong. Once the first probes arrived, we found that the martian atmosphere has no nitrogen, is therefore much thinner than predicted, and consists mostly of carbon dioxide instead of oxygen.

Just like then, however impressive today's equipment and theoretical work may be, scientists still recognize that they must take any theories about these hot Jupiters with much skepticism. "The models are certainly wrong," says Burrows. "We are making as many mistakes as possible as fast as possible so we can get it right later."

Still, as more transiting exoplanets show up in space telescopes and the big ground-based telescopes of the future, the data will become better and the models more sophisticated. More importantly, the new data could include Earth-sized planets located in Earth-sized orbits of Sun-like stars. If that happens, the improving models will make it possible for scientists to understand more quickly what they see on those extrasolar Earths.

And what if they detect oxygen in the atmosphere of one of those planets? To put it mildly, the impact of that discovery would be breathtaking.

Watch two simulations detailing how HD 189733b orbits around its star at www.Astronomy.com/toc.

The Sky this Month

Martin Ratcliffe and Alister Ling describe the solar system's changing landscape as it appears in Earth's sky.

February 2010

Long views of Mars and Saturn

Several major planets, and at least one minor one (the asteroid Vesta), give solar system observers plenty of targets for a night under the stars. The two brightest objects — Venus and Jupiter — pass close to each other low in evening twilight in mid-February.

Mars and Saturn rule the sky from nearly dusk until dawn. The Red Planet reached its peak in January and has now begun to dim, although it still ranks among the sky's brightest points of light.

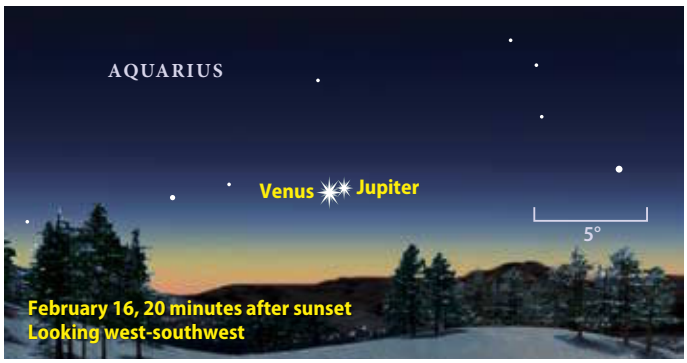
The ringed planet will peak in March and looks spectacular through a telescope. If you last through the night or simply get up at dawn, you'll spot Mercury low in the southeast in early February.

Let's begin our tour of the sky looking toward the west shortly after sunset. This is the stage where Venus and Jupiter will trade places.

Jupiter slides out of view in February as its orbital motion takes it toward the far side of the Sun from our perspective. **Venus**, on the other hand, starts the month on the Sun's far side. But its faster orbital speed quickly carries it east of the Sun, causing it to climb higher in the evening sky.

On February 1, Jupiter sets 100 minutes after sunset. At magnitude –2.0, it shines through the twilight glow with ease.

That same evening, Venus hides in the Sun's glare. For those with a clear, unobstructed western horizon, Venus may reappear around February 10. It then shines at magnitude –3.9 and stands 3° above the horizon 15 minutes after sunset. If you're able to spot Venus this early, use binoculars to pick up Jupiter some 5° higher in the bright twilight.



Venus and Jupiter slide past each other in mid-February. The two objects shine brilliantly but will be hard to spot, even through binoculars, in the bright twilight shortly after sunset. *Astronomy:* Roen Kelly

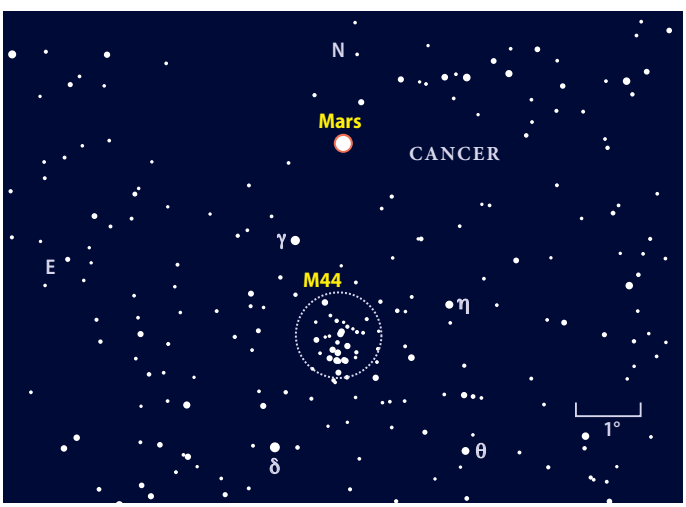
The gap between the two planets closes quickly. On February 16, they pass within a single Moon-width of each other. Look for the pair through binoculars starting about 20 minutes after sunset.

Venus will be easier to see, although it lies only 3° high and sets 40 minutes after the Sun. Jupiter appears to Venus' upper right. Seeing the two planets won't be easy. Count yourself lucky — and skillful — if you can spot them through the twilight.

This marks Jupiter's last hurrah for its current apparition. It reaches conjunction with the Sun February 28 and won't return to view until mid-March, this time in the predawn sky.

Venus continues to climb away from the Sun as February progresses. By the 28th, it lies 4° above the western horizon 30 minutes after sunset and sets 25 minutes later. Venus won't reach greatest

— *Continued on page 45*



Mars treks just north of the Beehive star cluster (M44) in Cancer the night of February 6/7. Binoculars will provide the best view of this attractive conjunction. *Astronomy:* Roen Kelly

40 Venus and Jupiter pass each other
40 Mars joins the Beehive
45 Meteor watch
45 Rising Moon
46 When to view the planets
46 View Saturn's family of moons
46 Comet search
47 Locating asteroids
47 Mercury in the morning

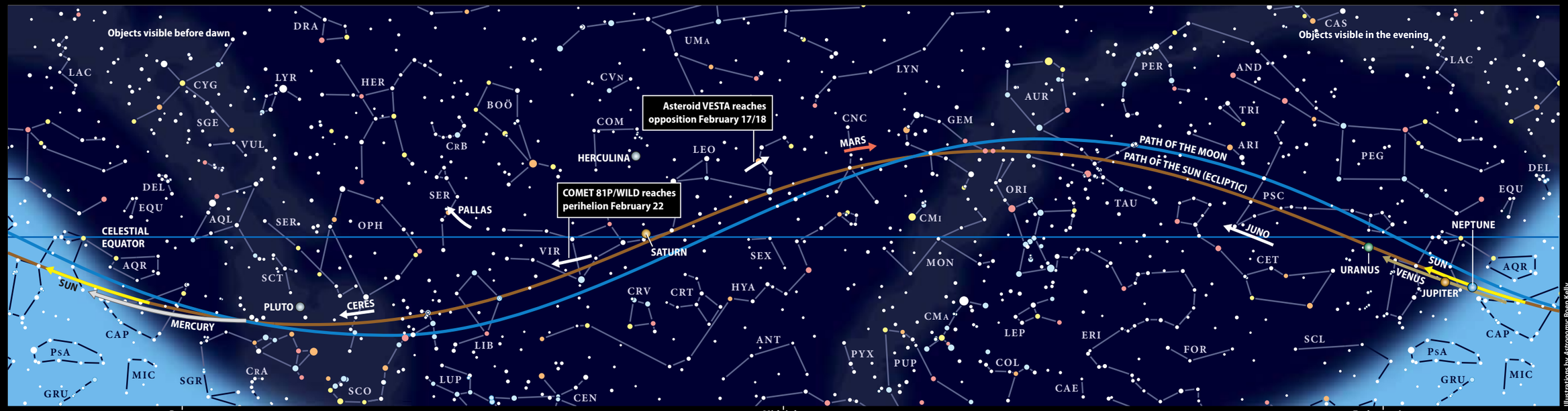
Visible to the naked eye
Visible with binoculars
Visible with a telescope

Planets in February 2010

This map unfolds the entire night sky from sunset (at right) until sunrise (at left).
Arrows and colored dots show motions and locations of solar system objects during the month.

Astronomy magazine

Path of the planets



Illustrations by *Astronomy*: Roen Kelly

MOON PHASES

16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

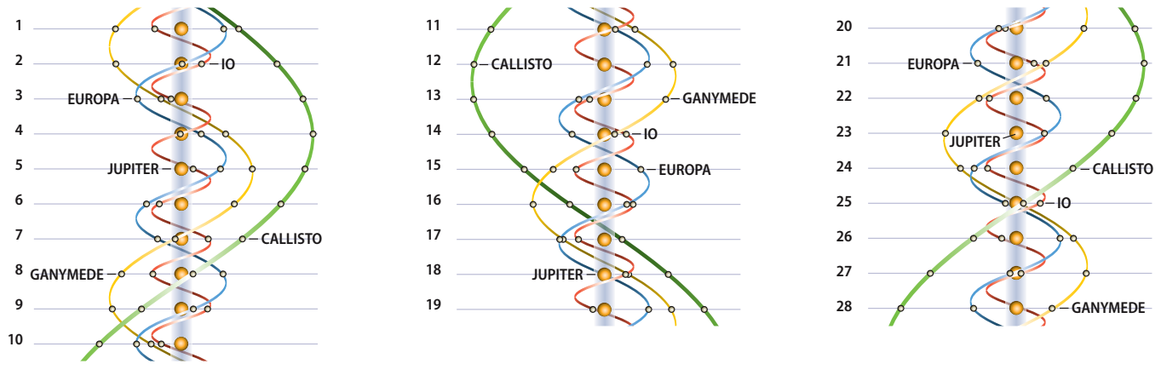
28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.
Note: Moons vary in size due to distance from Earth and are shown at 0h Universal Time.

PLANETS	MERCURY	VENUS	MARS	• CERES	JUPITER	SATURN	URANUS	NEPTUNE	• PLUTO
Date	February 1	February 28	February 15	February 15	February 1	February 15	February 15	February 15	February 15
Magnitude	–0.2	–3.9	–1.0	8.9	–2.0	0.7	5.9	8.0	14.1
Angular size	6.2"	10.0"	13.4"	0.4"	33.4"	19.1"	3.4"	2.2"	0.1"
Illumination	71%	98%	99%	97%	100%	100%	100%	100%	100%
Distance (AU) from Earth	1.082	1.670	0.701	3.008	5.902	8.687	20.957	31.011	32.390
Distance (AU) from Sun	0.445	0.726	1.656	2.743	4.996	9.489	20.096	30.023	31.786
Right ascension (2000.0)	19h16.0m	23h27.2m	8h28.7m	17h21.6m	22h21.3m	12h17.1m	23h41.9m	21h53.7m	18h19.3m
Declination (2000.0)	–21°58'	–5°03'	23°34'	–20°02'	–11°15'	0°51'	–2°45'	–13°15'	–18°17'

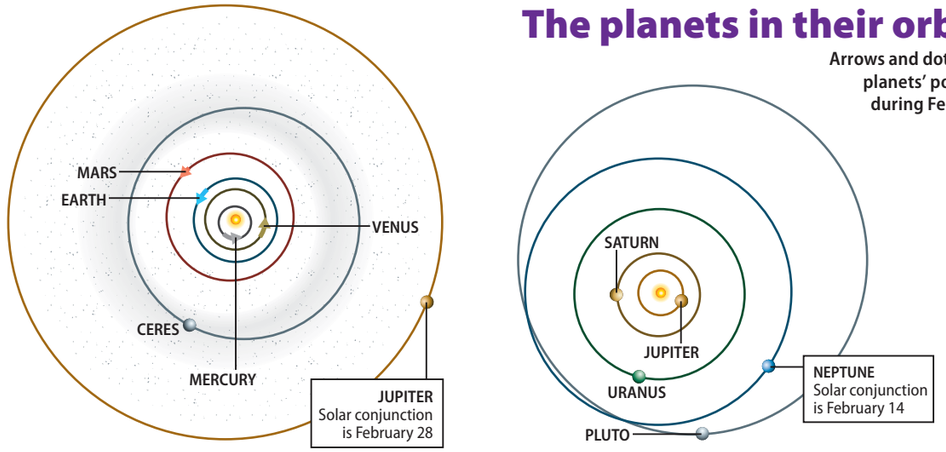
Jupiter's moons

Dots display positions of Galilean satellites at 8 P.M. EST on the date shown.
South is at the top to match the view through a telescope.



The planets in their orbits

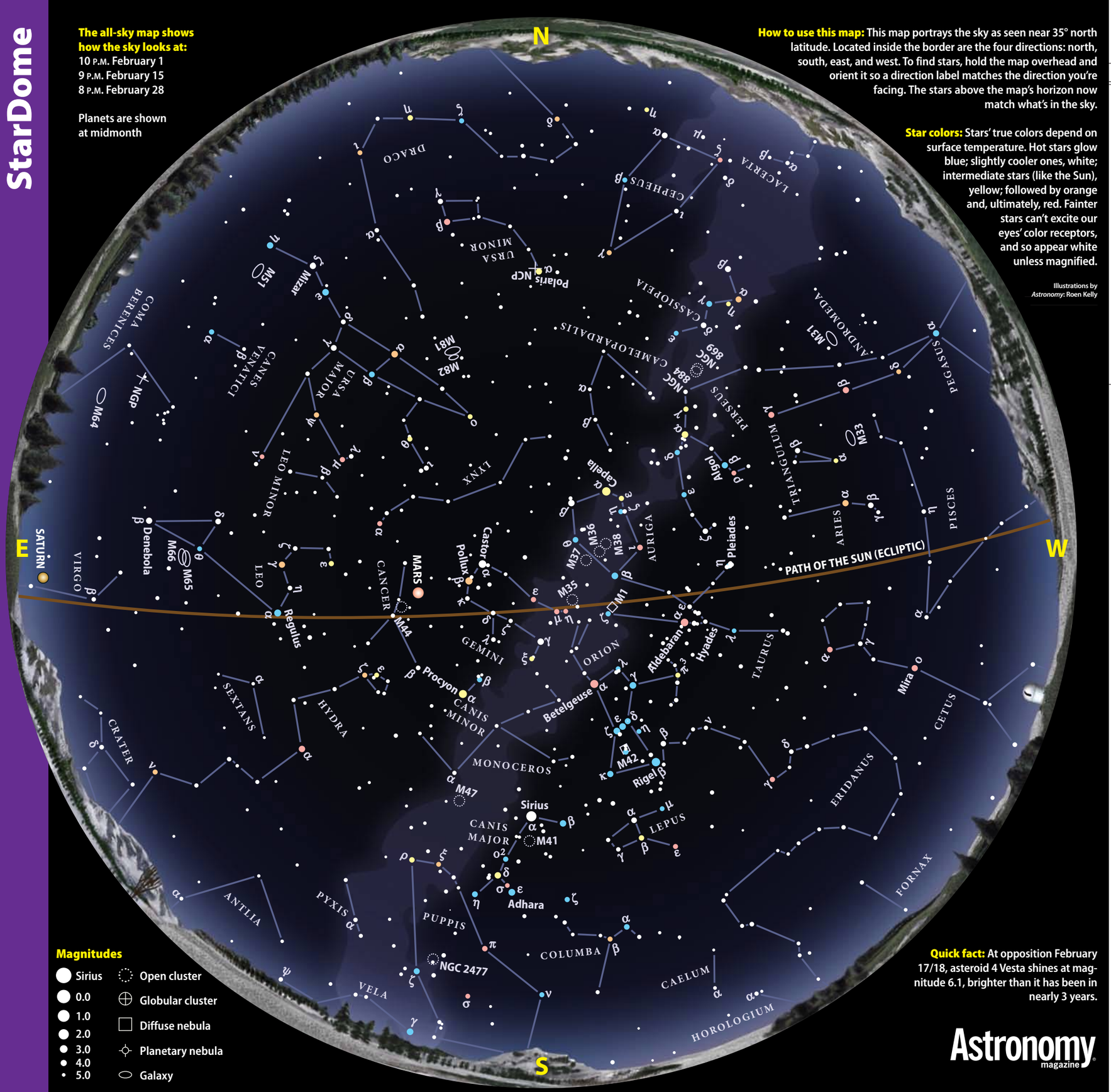
Arrows and dots show planets' positions during February.



StarDome

The all-sky map shows how the sky looks at:
10 P.M. February 1
9 P.M. February 15
8 P.M. February 28

Planets are shown at midmonth



Magnitudes

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

How to use this map: This map portrays the sky as seen near 35° north latitude. Located inside the border are the four directions: north, south, east, and west. To find stars, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

Star colors: Stars' true colors depend on surface temperature. Hot stars glow blue; slightly cooler ones, white; intermediate stars (like the Sun), yellow; followed by orange and, ultimately, red. Fainter stars can't excite our eyes' color receptors, and so appear white unless magnified.

Illustrations by *Astronomy*: Roen Kelly

Quick fact: At opposition February 17/18, asteroid 4 Vesta shines at magnitude 6.1, brighter than it has been in nearly 3 years.

Astronomy magazine

February 2010

Note: Moon phases in the calendar vary in size due to the distance from Earth and are shown at 0h Universal Time.

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28						

Calendar of events

2 The Moon passes 8° south of Saturn, 9 P.M. EST

5 Last Quarter Moon occurs at 6:48 P.M. EST

7 The Moon passes 1.1° north of Antares, 2 P.M. EST

12 The Moon passes 2° north of Mercury, 1 A.M. EST

The Moon is at apogee (252,613 miles from Earth), 9:07 P.M. EST

13 New Moon occurs at 9:51 P.M. EST

14 Neptune is in conjunction with the Sun, 6 P.M. EST

16 The Moon passes 6° north of Uranus, 2 P.M. EST

18 Asteroid Vesta is at opposition, 1 A.M. EST

21 First Quarter Moon occurs at 7:42 P.M. EST

22 Comet 81P/Wild is at perihelion (148.5 million miles from the Sun), noon EST

Special observing date

22 Comet 81P/Wild glows brightest (9th magnitude) around the time it makes its closest approach to the Sun.

25 The Moon passes 5° south of Mars, midnight EST

27 The Moon is at perigee (222,344 miles from Earth), 4:39 P.M. EST

28 Jupiter is in conjunction with the Sun, 6 A.M. EST

Full Moon occurs at 11:38 A.M. EST

See tonight's sky in Astronomy.com's STARDOME

— *Continued from page 40*

elongation from the Sun until August, but it improves dramatically well before then. It will appear fairly high in a dark sky by late spring.

If you want to spot **Uranus**, do so in early February before it sinks into the twilight. You'll need binoculars to see the distant planet. On February 1, it lies about 20° above Jupiter. To find Uranus, first locate Lambda (λ) Piscium in the Circlet asterism of Pisces the Fish. If you place Lambda at the 1-o'clock position near the edge of your binoculars' field of view, the planet will be near the field's center.

Mars is a spectacular object all month. It reached opposition January 29 and remains near its best throughout February. You can find the bright ruddy object in the eastern sky at dusk. Mars shines at magnitude –1.3 February 1 and fades noticeably, to magnitude –0.6, by the 28th. Still, that makes it brighter than any nighttime star except Sirius, which lies well to Mars' right these February evenings. Mars easily outshines Castor and Pollux, Gemini's brightest stars, which lie northwest of the planet.

Mars treks westward against the background stars of northern Cancer during February. It passes some 3° north of the bright Beehive star cluster (M44) the night of February 6/7, but they remain close for several days both before and after. Binoculars will provide the best view of this close encounter.

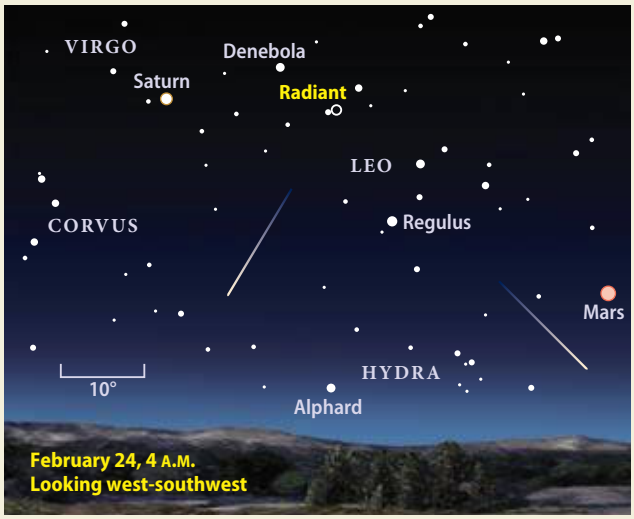
The planet's westward motion slows this month. In March, it will come to a standstill and then begin to move eastward relative to the starry backdrop.

A waxing gibbous Moon approaches Mars from the west during February's final week. On the 25th, the Moon passes 5° south of Mars.

Mars' apparent diameter shrinks from 14" to 12" during

Martin Ratcliffe *provides professional planetarium development for Sky-Skan Inc. in Nashua, New Hampshire. Meteorologist* **Alister Ling** *works for Environment Canada in Edmonton, Alberta.*

Meteor watch



The Delta Leonid meteor shower peaks before dawn February 24. Expect to see two or three meteors above the sporadic rate between 4 A.M. and 5 A.M., once the gibbous Moon sets. *Astronomy*: Roen Kelly

Minor showers and sporadics prowl

Meteor observers consider February and March to be the quietest time of the year. No major showers occur between early January's Quadrantids and late April's Lyrids. Sporadic meteors can occasionally flash to brilliance, however, so it pays to keep at least one eye on the sky. Their rates typically run about 5 meteors per hour from a dark site.

A couple of additional meteors per hour should streak across the sky before dawn February 24. That's when a minor shower known as the Delta Leonids peaks. The best views will come between 4 A.M. and 5 A.M., after the waxing gibbous Moon sets. Delta Leonid meteors appear to radiate from the tail of Leo the Lion and travel more slowly than typical meteors.

Rising Moon

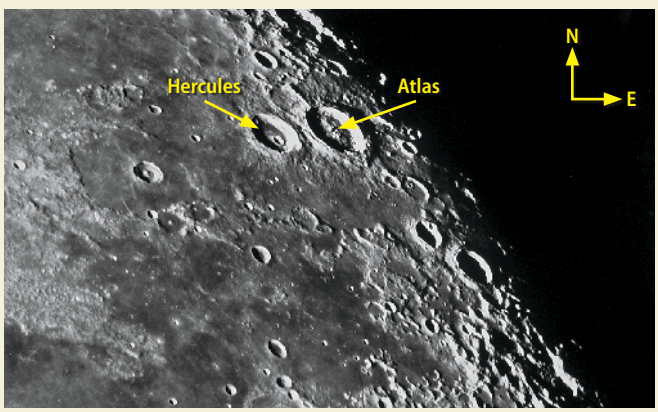
Fix your eyes on a pair of lunar musclemen

The Moon's northeastern quadrant features a prominent pair of craters: Atlas and Hercules. In mythology, no one matched these gods' prodigious feats of strength. It seems appropriate that the lunar features named for them appear so striking.

The craters' chiseled forms stand out well the night of February 1/2. The setting Sun then illuminates their eastern rims while their western walls cast crisp dark shadows into their depths.

Atlas sports a jumble of central peaks. Hercules' peaks, on the other hand, lie buried beneath the lava that rose through its floor long after the impact that gouged this crater. Look closely at Hercules' center, and you might see a small bump, which astronomers suspect is the remnant peak. It lies just north of a lovely young crater, Hercules G, that just missed being the crater's bull's-eye.

An apron of debris surrounds each crater bowl. Under the low Sun angle, can you tell which apron drapes over the other? If so, consider yourself an expert — even astronomers disagree as to which one formed first. Compare the lay of the land at lunar sunset to that at lunar sunrise 2 weeks later (on the evenings of February 17 and 18). Notice how the dark shadows and bright rims appear reversed when sunlight comes from the opposite direction.



The large craters Atlas and Hercules stand out under grazing sunlight. This view shows the region under a setting Sun, mimicking the view you'll see the night of February 1/2. *Consolidated Lunar Atlas*/UA/LPL

For a few days after First Quarter Moon (February 21), it's lunar high noon in this region. Without any shadows, Atlas practically disappears. But Hercules' dark lava lake contrasts well with its neighboring light-hued pit.

When to view **the planets**

EVENING SKY	MIDNIGHT	MORNING SKY
Venus (west)	Mars (southwest)	Mercury (southeast)
Mars (east)	Saturn (southeast)	Mars (northwest)
Jupiter (west)		Saturn (southwest)
Uranus (west)		

Saturn's brightest moons all lie near the ringed planet the night of February 1/2. Iapetus lies farthest away, to the west-southwest, while Tethys, Dione, Rhea, and Titan appear closer together. *Astronomy*: Roen Kelly

February, but that's still big enough to show detail through 6-inch and larger telescopes. Seeing the planet's subtle coloring and conspicuous dark and bright features is an experience you won't soon forget. Don't pass up this opportunity to view Mars through a telescope — the Red Planet won't appear bigger or brighter until 2014.

Excellent views of Mars through a telescope come whenever it lies at least 40° above the horizon. From mid-northern latitudes in mid-February, this occurs after 7 P.M. local time.

By waiting until then, the light from Mars passes through less of Earth's image-distorting atmosphere. The best views come shortly before midnight, when Mars crests about 75° high (just 15° from the zenith) in the south.

The only constant on Mars' surface this month is its stark-white north polar cap. The cap should appear conspicuous whenever you view the planet because its north pole now tilts toward Earth.

Mars' most prominent dark feature, Syrtis Major, lies near the center of the planet's disk at 11 P.M. EST February 17. You can see it east of the central meridian (the north-south line that divides Mars in two) for several evenings before the 17th. Look for it west of the central meridian for several days thereafter. Mars' blander side faces Earth on evenings at the beginning and end of February.

As you shift your gaze from Mars eastward toward Saturn, pause a few minutes in Leo to look for the asteroid **Vesta**. Vesta reaches opposition and peak visibility February 17/18, when it glows at magnitude 6.1. However, it remains bright enough all month to see easily through binoculars and show up barely to unaided eyes under a dark sky.

The key is knowing where to look. On February 1, Vesta forms a rough equilateral triangle with Algieba (Gamma [γ] Leonis) and Eta (η) Leonis. Vesta lies 6° east of the latter star. During the next 2 weeks, Vesta slides closer to Algieba. The asteroid passes 0.2° south of the star February 16/17, and it lies 0.3° west of Algieba at opposition the next night.

Beautiful **Saturn** lies one constellation east of Leo, in Virgo the Maiden. You can spy the ringed planet low in the east after 10 P.M. local time February 1 and after 8 P.M. at month's end. It remains on view the rest of the night, reaching its highest point in the south after midnight.

Saturn begins the month 1° north of the 4th-magnitude star Eta Virginis. The planet inches westward to stand 2° northwest of the star by February's close.

Although Saturn lies closer to Eta, the planet's brightness nearly matches Virgo's brightest star, 1st-magnitude Spica. Note the color difference between blue-white Spica and golden Saturn.

The view of Saturn through a telescope is beyond compare. The rings immedi-

Comet search

Spy a pair of cometary fuzzballs

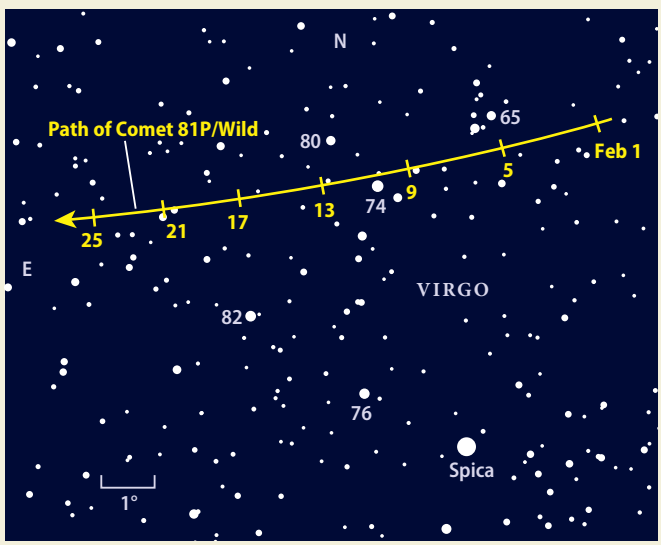
February offers two comets that should be within reach of 4-inch telescopes under dark skies. Your best views of these 9th-magnitude fuzzballs should come the weekend of February 13, when the Moon is close to its new phase and not scattering light across the sky.

Comet 81P/Wild floats a few degrees north of Virgo's luminary, 1st-magnitude Spica. The pair rises around 11 P.M. local time and climbs reasonably high by 1 A.M.

The month's second nice comet is C/2007 Q3 (Siding Spring). By 10 P.M., it already lies 15° above the northeastern horizon. This comet undergoes a neat transformation during February.

A comet's tail usually appears fan-shaped. This happens through a combination of the Sun's influence and the comet's path through space. Material ejected from the dirty snowball's nucleus spreads out in a sheet along the comet's orbital plane, bounded on one side by the ephemeral gas tail with the rest gradually trailing behind.

On February 17, give or take a couple of nights, we see C/2007 Q3's fan nearly edge-on, which gives the tail a spiky look. If we're lucky, the gas tail will be long and bright enough to poke out on the other side as an "anti-tail," a fainter version of what we saw a year ago with Comet C/2007 N3 (Lulin).



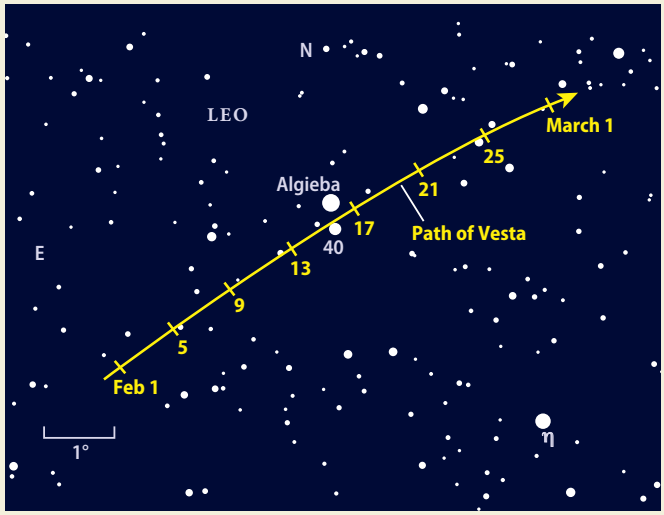
Comet 81P/Wild should glow around 9th magnitude as it treks eastward through Virgo. In early February, it passes about 5° north of Virgo's brightest star, 1st-magnitude Spica. *Astronomy*: Roen Kelly

A bright rock keeps bright company

It would be nice if the sky provided a big arrow to point to an asteroid's location, but this month observers experience the next best thing. On the night of February 16/17, asteroid 4 Vesta threads the needle between the 2nd-magnitude star Algieba (Gamma [γ] Leonis) and its 5th-magnitude southern neighbor, 40 Leonis. Walk outside with binoculars, aim at Algieba, and our 6th-magnitude asteroid lies smack between the two stars. With the stars as guides, you can see Vesta move in just a few hours.

Throughout February, the large main-belt asteroid remains in the same binocular field as Algieba. This star is a gem, too. Point your telescope at it, pump up the power past 100x, and you'll see Algieba as a double star. Both components glow with a yellowish hue. The secondary lies a comfortable 4.5" to the primary's southeast. You'll have another chance to see Vesta move the evening of the 24th, when it approaches a 7th-magnitude field star.

German astronomer Heinrich Olbers discovered Vesta in March 1807. (Today, we know Olbers best for asking the question, "Why is the sky dark at night?") Vesta is one of the largest asteroids, with a diameter of 330 miles.



Vesta treks through western Leo this month. It slips between 2nd-magnitude Algieba and its 5th-magnitude neighbor, 40 Leonis, the night of February 16/17. *Astronomy:* Roen Kelly

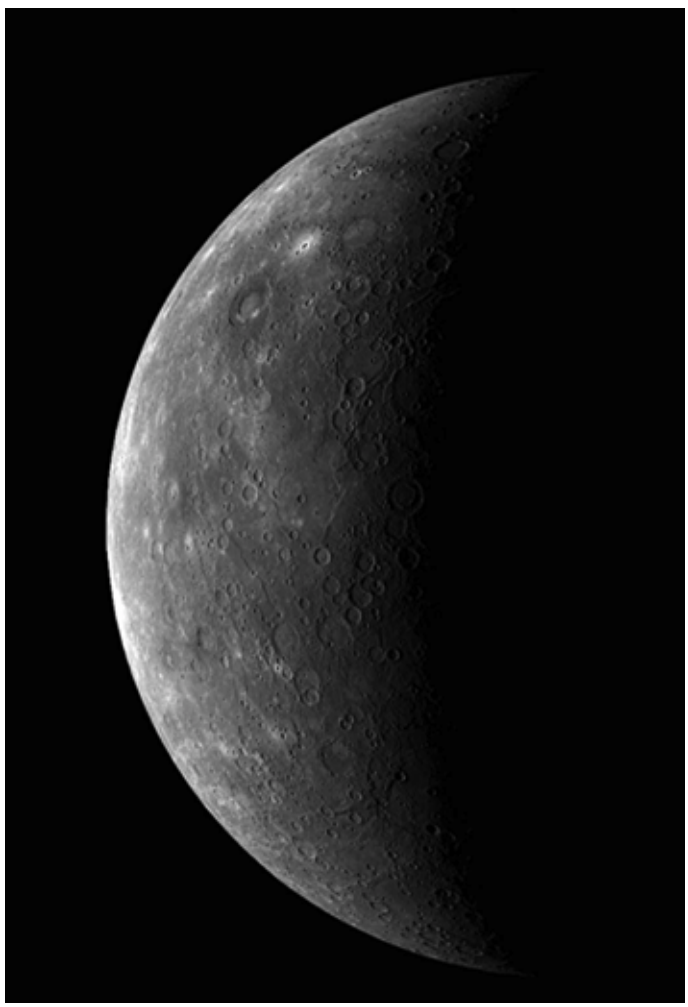
ately grab the attention of novice and experienced observers alike. The tilt of the rings narrows slightly this month, from 5° to 4°. The good news: The overall trend for 2010 has the rings opening wider to our view. By the end of the year, they will tilt 10° to our line of sight.

Although the rings are the most spectacular aspect of Saturn's telescopic appearance, the planet also offers an intriguing family of moons. The easiest to spot is 8th-magnitude Titan, which shows up as a point of light through any telescope. You can find it near Saturn February 2 (north of the planet), February 10 (southwest), February 18 (northeast), and February 26 (southwest). On other nights, Titan lies either east or west of the planet.

You'll need a 4-inch scope to see the next group of saturnian satellites. Tethys, Dione, and Rhea glow at 10th magnitude and never stray far from the planet. Outer Iapetus takes a more leisurely and elongated orbit around Saturn. On the evening of February 1, however, it lies relatively close to the planet. Look for this 11th-magnitude moon 3' west-southwest of Saturn's disk. That same night, Titan, Dione, and Rhea stand between Iapetus and Saturn while Tethys appears to Saturn's east.

During the next 2 weeks, Iapetus moves farther west of Saturn. As it does so, the moon turns its brighter side in our direction. Iapetus appears brightest (10th magnitude) at greatest western elongation February 17/18. It then lies nearly 10' from the planet.

Our solar system tour doesn't end until after morning twilight begins. **Mercury** appears against the twilight sky in early February. On the 1st, the "morning star" shines at magnitude –0.2 and stands 7° high in the southeast 30 minutes before sunrise. A telescope will show you Mercury's 6"-diameter disk and gibbous phase. On February 12, a slender crescent Moon passes 4° to Mercury's left. The innermost planet disappears into the brightening dawn sky a few days later.



Mercury's fine morning appearance continues in early February, when it lies low in the southeast before sunrise. Although you won't see the battered surface revealed by NASA's MESSENGER spacecraft, just glimpsing the innermost planet provides a thrill. NASA/JHUAPL/CIW

Explore our neighborhood of galaxies

Some 50 galaxies crowd around the Milky Way. Astronomers call them the Local Group. **by Richard Talcott; illustration by Roen Kelly**

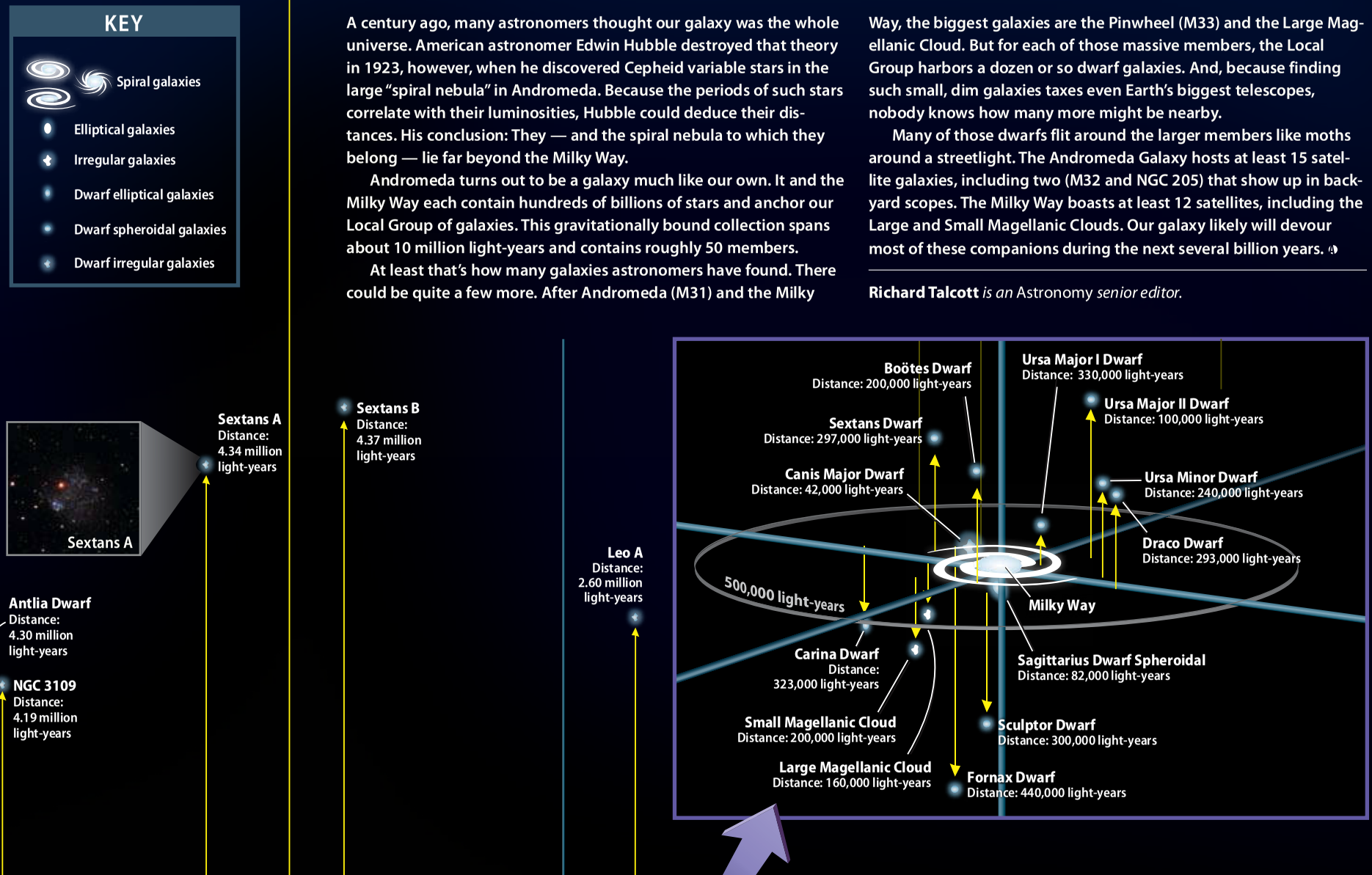
A century ago, many astronomers thought our galaxy was the whole universe. American astronomer Edwin Hubble destroyed that theory in 1923, however, when he discovered Cepheid variable stars in the large "spiral nebula" in Andromeda. Because the periods of such stars correlate with their luminosities, Hubble could deduce their distances. His conclusion: They — and the spiral nebula to which they belong — lie far beyond the Milky Way.

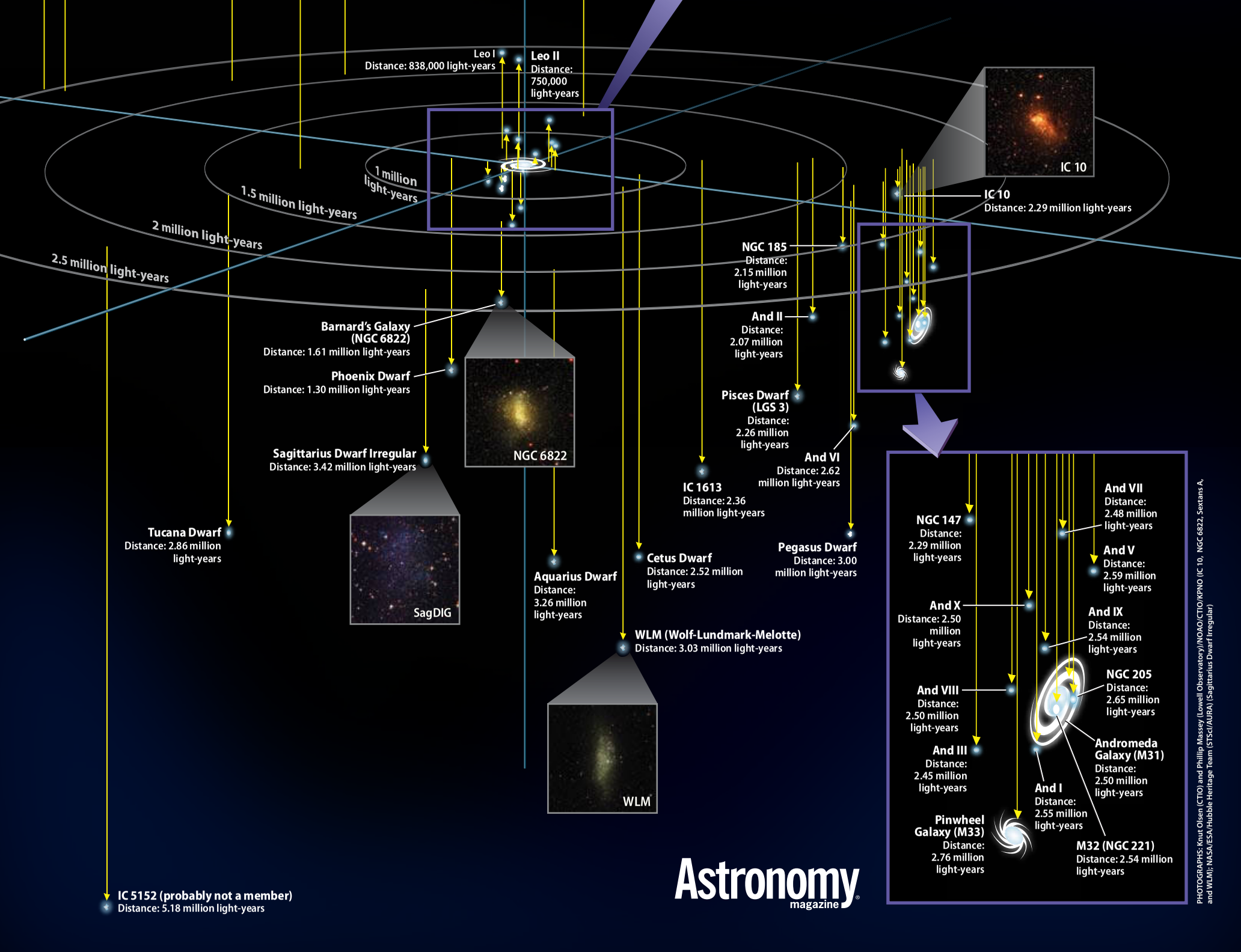
Andromeda turns out to be a galaxy much like our own. It and the Milky Way each contain hundreds of billions of stars and anchor our Local Group of galaxies. This gravitationally bound collection spans about 10 million light-years and contains roughly 50 members.

At least that's how many galaxies astronomers have found. There could be quite a few more. After Andromeda (M31) and the Milky Way, the biggest galaxies are the Pinwheel (M33) and the Large Magellanic Cloud. But for each of those massive members, the Local Group harbors a dozen or so dwarf galaxies. And, because finding such small, dim galaxies taxes even Earth's biggest telescopes, nobody knows how many more might be nearby.

Many of those dwarfs flit around the larger members like moths around a streetlight. The Andromeda Galaxy hosts at least 15 satellite galaxies, including two (M32 and NGC 205) that show up in backyard scopes. The Milky Way boasts at least 12 satellites, including the Large and Small Magellanic Clouds. Our galaxy likely will devour most of these companions during the next several billion years.

Richard Talcott *is an* Astronomy *senior editor.*




Leo I
Distance: 838,000 light-years
Leo II
Distance: 750,000 light-years
1 million light-years
1.5 million light-years
2 million light-years
2.5 million light-years
IC 10
IC 10
Distance: 2.29 million light-years
NGC 185
Distance: 2.15 million light-years
And II
Distance: 2.07 million light-years
Barnard's Galaxy (NGC 6822)
Distance: 1.61 million light-years
Phoenix Dwarf
Distance: 1.30 million light-years
NGC 6822
Pisces Dwarf (LGS 3)
Distance: 2.26 million light-years
And VI
Distance: 2.62 million light-years
Sagittarius Dwarf Irregular
Distance: 3.42 million light-years
IC 1613
Distance: 2.36 million light-years
Tucana Dwarf
Distance: 2.86 million light-years
SagDIG
Aquarius Dwarf
Distance: 3.26 million light-years
Cetus Dwarf
Distance: 2.52 million light-years
Pegasus Dwarf
Distance: 3.00 million light-years
WLM (Wolf-Lundmark-Melotte)
Distance: 3.03 million light-years
WLM
NGC 147
Distance: 2.29 million light-years
And VII
Distance: 2.48 million light-years
And V
Distance: 2.59 million light-years
And X
Distance: 2.50 million light-years
And IX
Distance: 2.54 million light-years
NGC 205
Distance: 2.65 million light-years
And VIII
Distance: 2.50 million light-years
Andromeda Galaxy (M31)
Distance: 2.50 million light-years
And III
Distance: 2.45 million light-years
And I
Distance: 2.55 million light-years
Pinwheel Galaxy (M33)
Distance: 2.76 million light-years
M32 (NGC 221)
Distance: 2.54 million light-years
IC 5152 (probably not a member)
Distance: 5.18 million light-years
Astronomy magazine
PHOTOGRAPHS: Knut Olsen (CTIO) and Phillip Massey (Lowell Observatory)/NOAO/CTIO/KPNO (IC 10, NGC 6822, Sextans A, and WLM); NASA/ESA/Hubble Heritage Team (STScI/AURA) (Sagittarius Dwarf Irregular)

Ask Astro

Astronomy's experts from around the globe answer your cosmic questions.

The hunt for Earth's brother

Q: What is the largest rocky extrasolar planet ever found and its size comparison to Earth? — John Garfield, Rochester Hills, Michigan

A: We have detected only one transiting planet that has a mass below 10 Earth masses. This world, CoRoT-7b (named after the European Convection, Rotation and planetary Transits satellite) has a radius 1.7 times that of Earth. The planet is just around 4.8 times Earth's mass. This gives it a density about the same as Earth's, implying that it is likely rocky in composition. This makes CoRoT-7b the only confirmed rocky extrasolar planet, and therefore the largest exoplanet of this composition.

Astronomers use three methods to detect "terrestrial" planets — rocky planets with sizes or masses similar to Earth. The methods are microlensing, radial velocity, and transits. We can determine both the mass and radius only of transiting planets (when the planet passes in front of its star and blocks some light). We need both characteristics to determine the planet's density and therefore whether it is made primarily of rock, ice, or gas.

Radial velocity, microlensing, and transit searches have revealed some 20 planets with masses ranging from 1.9 to 10 times Earth's mass; many of those planets are likely to be primarily rocky in composition. However, for the majority of them we don't know the radius, so the composition is purely a matter of speculation. **— Scott Gaudi,** Ohio State University, Columbus

CoRoT-7b (in the foreground of this illustration), is the only confirmed rocky exoplanet. It orbits so close to its star that its surface is likely molten rock. ESO/L. Calcada

PLANETARY OBSERVATIONS

Q: I have an 8-inch telescope but can see only Mars as orange instead of red. All other planets appear colorless. Why? — Ed Lastella, White Plains, New York

A: Of the five naked-eye planets, only Mars has a noticeable color through a medium-sized telescope. And, although we refer to it as the Red Planet, your perception of it as orange is correct. Mars' color originates from several types of iron oxides (including hematite, ferrihydrite, and goethite) that blanket the planet's surface. For an equivalent, think of the iron oxide on Earth in red Georgia clay.

Mercury, with no atmosphere, appears grayish-white, and Venus, with a thick atmosphere, looks bright white. Images of Jupiter — especially those from spacecraft — show a lot of color, but through your telescope you'll see two thick (and several thin) brownish belts. Even the Great Red Spot's color has faded during the past few decades. Most observers now describe it as salmon-pink. And Saturn displays a subtle mix of yellows, tans, and whites.

But have you tried viewing Uranus and Neptune? Both are easy targets through an 8-inch scope, and each displays hues not seen on the other planets. Uranus appears grayish-green to green, depending on your eyes' color perception.

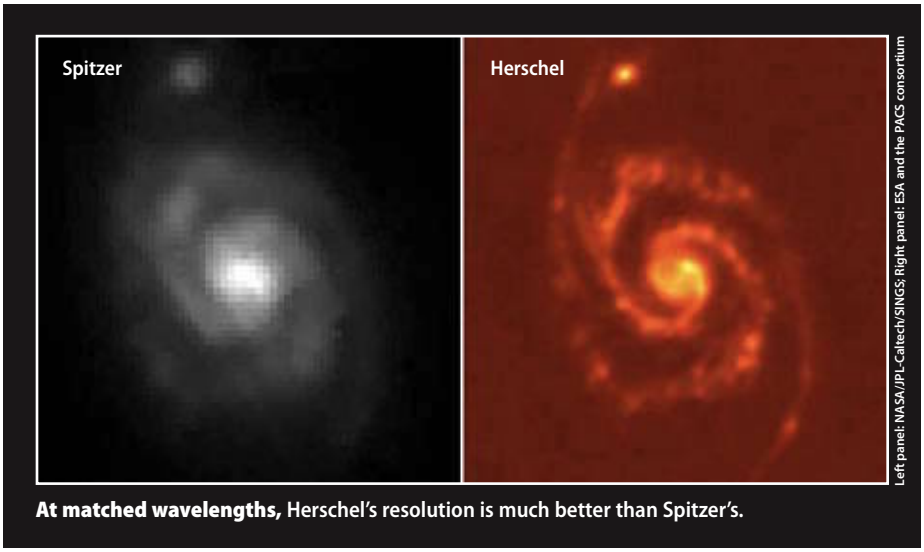
I rank Neptune as the "king of color" among the planets. It appears vivid blue to most observers. For these outer planets, start with an eyepiece that provides a magnification of around 75x. Both objects will appear small, but the colors should stand out. Then use other eyepieces to increase the power until you find the view that pleases you most. **— Michael E. Bakich,** Senior Editor

SPACE EYE FOR AN EYE

Q: Why can't the recently launched Herschel Space Telescope produce sharper images than the Spitzer Space Telescope?
— Thomas Hofstätter, Vienna, Austria

A: While both Herschel and Spitzer are infrared telescopes, they work in different wavelength ranges. Spitzer operates in wavelengths from 3.6 to 160 microns while Herschel operates from 70 to 600 microns. Spitzer reaches much shorter wavelengths than Herschel — about 20 times shorter in the case of the 3.6-micron band.

However, Spitzer has a mirror about 33 inches (85 centimeters) wide while Herschel has an 11.5-foot (3.5 meters) mirror. When observing, the telescope's diameter is a major factor for what you can see. **In the shortest wavelength bands, Spitzer produces sharper images than Herschel. But when you compare apples with apples, Herschel exceeds Spitzer's capability. — Dave Clements,** Imperial College London



At matched wavelengths, Herschel's resolution is much better than Spitzer's.

BABY STAR CLUSTERS

Q: Have astronomers seen massive young clusters like the Milky Way's Arches Cluster in other spiral galaxies? — James Smith, San Jose, California

A: Yes. These clusters are harder to find in distant galaxies, but locating them is possible with modern observatories. The Hubble Space Telescope dramatically opened up this field of research. In fact, astronomers have not only found other massive young clusters in distant galaxies, but they've also found clusters that dwarf the Arches Cluster by a factor of more than 100 in mass. For example, the beautiful Antennae interacting galaxy system harbors thousands of these clusters, as do virtually all starburst galaxies and a handful of other environments.

Astronomers commonly refer to these infant massive star clusters as "super star clusters." If we take the properties of a super star cluster, such as its mass, radius, and stellar population, and use computer models to let it evolve for billions of years, it is indistinguishable from the ancient globular clusters that orbit the Milky Way today.

So the early universe must have contained super star clusters. Thus, these massive young clusters we see in the Antennae and other galaxies may actually provide us with clues about star formation in the early universe. **— Kelsey Johnson,** University of Virginia, Charlottesville

Our Sun is yellow, but the sky isn't. Visit www.Astronomy.com/toc to learn why.

CORRECT THIS MYTH

Q: Is it true that there are more stars in the universe than there are grains of sand on Earth? How could one calculate such figures? — Andy Johnston, Kalaheo, Hawaii

A: It's probably not true, yet we can't answer with certainty. But this question is a wonderful example of what we sometimes call a Fermi problem, after physicist Enrico Fermi, who asked the "big" questions. The key to solving them is that you don't need to know the answer to any decimal places at all. You can be wrong by a factor of 10 and that's close enough.

We cannot see the whole universe, so it's difficult to say how many stars are in it. There simply has not been enough time for the light from the whole universe to travel to Earth since the Big Bang 13.7 billion years ago.

But if we limit ourselves to the visible universe, we can make up a reasonable answer. We know from counting the number of galaxies in images of deep space from the Hubble Space Telescope that there are about 10^{11} galaxies in the visible universe. The Milky Way has about 10^{11} stars in it. (It's a pretty big galaxy, as they go.) We know that value from counting the number of stars in the sky, then extrapolating using theoretical models of the stars' three-dimensional distribution. So that multiplies out to about 10^{22} stars.

Now how much sand is on Earth? That's also tricky because we can't see all the sand. But let's just look at the Sahara Desert. It has an area of 10^{17} square centimeters; we can measure it with GPS. Sand dunes in a layer at least 10 meters thick probably cover the desert. That's about 10^{20} cubic centimeters of sand.

Let's say a grain of sand is cube-shaped and roughly 0.1 centimeter across. That means each grain of sand has a volume of about 0.1^3, or 10^{-3} cubic centimeter.

Divide the volume of the Sahara sand dunes (10^{20} cubic centimeters) by the volume of a sand grain (10^{-3} cubic centimeter), and you get 10^{23} grains of sand. That's already more than all the stars in the visible universe. And that's an underestimate because we didn't count the other deserts, and the sand on all the world's beaches and under the oceans. So what you mentioned is just a myth — albeit an interesting one. **— Marc J. Kuchner,** NASA's Goddard Space Flight Center, Greenbelt, Maryland

Send your questions via e-mail to: **askastro@astronomy.com**; or write to **Ask Astro, P. O. Box 1612, Waukesha, WI, 53187.** Be sure to tell us your full name and where you live. Unfortunately, we cannot answer all questions submitted.

10 tips for Moon watchers

Mountain ranges, vast volcanic plains, and more than 1,500 named craters make the Moon a target you'll return to again and again. **by Michael E. Bakich**

The Moon offers something for every amateur astronomer. It's visible somewhere in the sky most nights, its changing face presents features one night not seen the previous night, and it doesn't take an expensive setup to enjoy it. To help you get the most out of viewing the Moon, I've developed these 10 simple tips. Follow them, and you'll be on your way to a lifetime of satisfying lunar observing.

1 Perform a "no optics" survey

The best way to begin your journey as a lunar observer is to learn the Moon's major features. Head out with a simple Moon map, and use just your eyes to identify our only natural satellite's top attributes.

As luck would have it, Stephen James O'Meara's "Secret Sky" column in the January 2010 issue deals with this very point. He gives a detailed description of naked-eye lunar features. Subscribers to *Astronomy* can visit www.Astronomy.com/OMeara to view this column (and all of O'Meara's columns) online.

2 The Full Moon is for romance

Contrary to what you might think, Full Moon is not the best time to observe our natural satellite, although that's the time when it's at its brightest. When the Moon is full, the Sun lies behind Earth (as we face the Moon) shining directly down on the lunar surface. Shadows are at their minimum lengths, and you can't see much detail. You can still observe the Moon when it's full, but the contrast between its light and dark sections will be better at other times.

3 View the Moon at "prime time"

Two intervals during the lunar "month" (from one New Moon to the next) are best for observers. The first begins shortly after New Moon and continues until 2 days past First Quarter. Amateur astronomers tend to favor this span because the Moon lies in the evening sky.

An equally good observing period starts about 2 days before Last Quarter and goes until the Moon lies so close to the Sun that it's lost in morning twilight. At these times, shadows are longer and features stand out in sharp relief. Another benefit you'll get when you observe the Last Quarter Moon is that the atmosphere before dawn usually appears steadier than it does after sunset. After sunset, a lot of heat remains in the atmosphere. As hot air rises and cooler air falls, the resulting turbulence leads to unstable air — what observers call bad seeing.

Michael E. Bakich *is a senior editor of* Astronomy.

4 The terminator will help you

During the two favorable periods described in #3, point your telescope anywhere along the line that divides the Moon's light and dark portions. Astronomers call this line the terminator. Before Full Moon, the terminator marks where sunrise is occurring. After Full Moon, sunset happens along the terminator.

Here you can catch the tops of mountains protruding just high enough to catch the Sun's light while surrounded by lower terrain that remains in shadow. Features along the terminator change in real time, and, during a night's observing, the differences you'll see through your telescope are striking.

5 The best scope for viewing the Moon

Nearly any telescope will do to observe lunar details. You'll get great views of the Moon through a 2.4-inch refractor, an 8-inch reflector, or an 11-inch Schmidt-Cassegrain telescope. Observers with several options (but not a permanent observatory) usually pick a scope they can set up many nights in a row. Observing on successive nights makes it easier to follow the terminator's progress.

6 Cut down the moonlight

Many observers employ either neutral density filters or variable polarizing filters to reduce the Moon's light. I prefer the latter because an observer can change how much light the filter transmits.

When should you observe the Moon?

During the next year, you'll get your best views of the Moon by selecting dates in the following table. The greatest details will lie on the sunlit portion of the Moon closest to the terminator. Point your telescope there for the best views.

In the evening sky	In the morning sky
February 16–24	February 3–12
March 17–25	March 5–13
April 16–23	April 4–12
May 16–22	May 4–12
June 14–21	June 2–10
July 13–20	July 2–9
August 12–18	August 30–September 6
September 10–17	September 29–October 5
October 9–16	October 28–November 4
November 8–15	November 26–December 3
December 7–15	December 26–January 2, 2011

You'll find six labeled maps to help you observe the Moon at www.Astronomy.com/toc.

Two other methods to reduce the Moon's brightness are to use high magnification or to add an aperture mask. High powers restrict the field of view, thereby reducing light throughput. An aperture mask causes your telescope to act like a much smaller instrument, but at the same focal length.

7 Turn on your best vision

Some years ago, my late observing buddy Jeff Medkeff introduced me to a better way of observing the Moon: Turn on a white light behind you when you observe between Quarter and Full phases. The light should be moderately bright (I suggest something in the 60-watt range), but neither your eyes nor the eyepiece should be in direct view of the fixture.

The addition of white light suppresses the eyes' tendency to dark adapt at night. Not dark adapting causes the eye to use normal daytime vision, which is of much higher quality than dark-adapted night vision. In essence, you'll see more detail because you're viewing with a better part of your eye.

8 Work from a list

One of the best ways to learn the Moon is to undertake an observing project. In the United States, the Astronomical League offers one such project, the Lunar Observing Club. You'll learn a lot about our satellite as you work through a list of 100 lunar features.

To receive a certificate, you must be a member of the league, either individually or through an astronomy club. For details about the club, see www.astroleague.org/al/obsclubs/lunar/lunar1.html.

In Britain, the British Astronomical Association coordinates lunar observing. Visit www.baalunarsection.org.uk.

9 Dig for the details

Of the 1,940 named lunar features, 1,545 are craters. Challenge yourself to see either how small a crater you can detect or how many craterlets in a given area you can observe. You'll need a detailed Moon map for this project.

For the second challenge, you can choose a lunar sea, but usually a large, flat-bottomed crater works best. For example, if you search the large crater Plato, you'll find four craterlets on its floor, each about 1.2 miles (2 kilometers) across. Lunar observers consider seeing these craters a test for a 6-inch telescope.

The Moon's terminator is the line that divides the lit region from the dark part. Because it's the line marking sunrise (before Full Moon) or sunset (after Full Moon), point your telescope toward it to see the best shadow details. North is up in this image, so you'll see it like this with your eyes. Jamie Cooper

10 Shoot the Moon

How can a celestial object that's so easy to photograph be so difficult to photograph well? The Moon is large and bright (only the Sun outshines it), and you can use any camera connected to any size telescope to image it. That's the easy part.

But the Moon also contains vast areas of low contrast that have little color differential. Recording those regions so they look like what your eyes see is the hard part.

Luckily, we live in the digital age. Unlike when astrophotographers used film, it costs nothing extra to take 200 images instead of just one. Examine them, throw away what you don't like, change one or more parameters (including the techniques you used to process the images) each time, and shoot some more as you continue to perfect your techniques.

How to start a meteorite collection

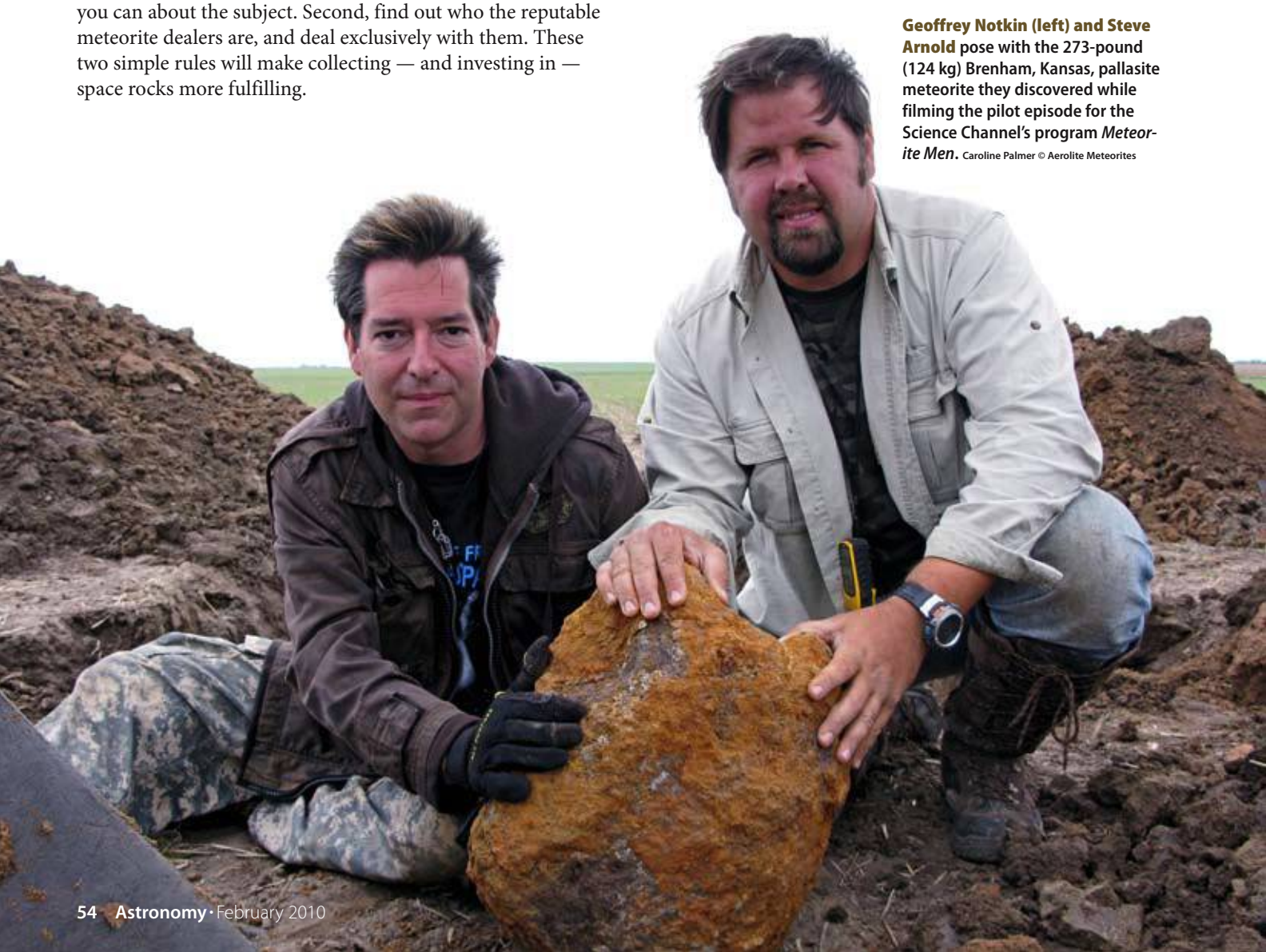
*Learn Contributing Editor **Raymond Shubinski**'s two main tenets of meteorite collecting, and meet some of the dealers he trusts.*

Collecting meteorites can be an exciting way to "touch" the cosmos. This hobby, unlike rock and mineral collecting, offers few specimens that have the visual appeal of fine minerals. The pleasure of meteorites comes from understanding how such rocks from space formed and how they eventually found their way into collectors' hands. But, lacking the means to explore the world and discover specimens yourself, how does one go about building a collection?

I have two basic rules for anyone who wants to put together an exciting and worthwhile meteorite collection. First, learn all you can about the subject. Second, find out who the reputable meteorite dealers are, and deal exclusively with them. These two simple rules will make collecting — and investing in — space rocks more fulfilling.

Most meteorites aren't cheap. As with any worthwhile endeavor, you will need to commit not only time but also money to this hobby.

Today's top resource for collecting meteorites is the Internet. However, a quick entry of "meteorites" into the Google search engine yields 2.2 million hits! The trick is sorting this information and being sure you deal with people you can trust. To help facilitate this, well-known meteorite dealers have developed both print and Internet resources to help collectors receive the best information.



Geoffrey Notkin (left) and Steve Arnold pose with the 273-pound (124 kg) Brenham, Kansas, pallasite meteorite they discovered while filming the pilot episode for the Science Channel's program *Meteorite Men*. Caroline Palmer © Aerolite Meteorites

A space-rock history lesson

If you want to be a meteorite collector, or if finding out more about these cosmic rocks interests you, read about the man who brought meteorites out of museums and into the hands of individuals, American meteoriticist Harvey H. Nininger (1887–1986).

Nininger was one of the first individuals to dedicate himself to searching for meteorites in the field. In 1942, he founded the American Meteorite Museum.

He sold part of his vast collection to the British Museum in 1958, and the rest of it to Arizona State University in 1960. Nininger wrote three books about meteorites, as well as his autobiography, *Find a Falling Star*. — *R. S.*

Michael E. Bakich library

First-class ethics

One of the major efforts to help collectors began with Anne Black and a number of friends who developed the International Meteorite Collectors Association (IMCA). This organization provides professional standards for dealers, including a code of ethics and a system of review that ensures reputable dealings with the public. At their web site, www.imca.cc, collectors can scan a list of the organization's directors, members, and more. New collectors will find information at www.meteorite.com, the virtual hub of the meteorite community.

Anne Black is also a meteorite dealer. She took early retirement about 3 years ago to pursue her passion for space rocks full time through her Colorado company, Impactika. At various mineral shows around the United States, you'll find Black in her motel room surrounded by a dazzling array of meteorites that she offers to her customers.

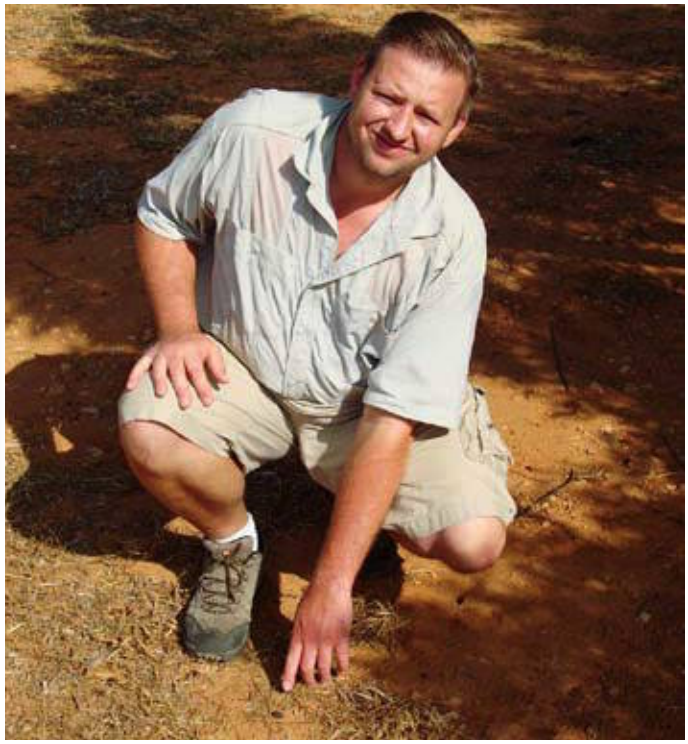
Black has sound advice for beginning collectors. "Start with the basics," she says. "Collect some nice irons, then some stony meteorites, and then move on to named pieces that have more history." One of Black's interests is the educational aspect of meteorites. Currently, she is translating a book French meteorite expert Alain Carion wrote for beginning collectors.

The Meteoritical Society is another outstanding source of information for collecting meteorites. This organization dates back to 1933 when it first convened at the Field Museum of Natural History in Chicago. One of the founding members was Harvey H. Nininger (see "A space-rock history lesson" above).

During and after World War II, the society nearly fell apart but reorganized in the 1960s. It operates on a nonprofit status and promotes high standards of scholarship by working with organizations such as the Geological Society of America and the Lunar and Planetary Institute. Membership is available to collectors as well as professionals.

Head west in the winter

The annual Tucson Gem and Mineral Show is the prime show for meteorite dealers. There, in February 2009, I found dealers Mike Farmer and Eric Olson only a short walk from Black's room. They jammed their area with beautiful cases filled with unbelievable specimens. Both have been in the business for



Meteorite hunter Michael Farmer found this small stone in an olive grove in Puerto Lápice, Spain, in 2007. The meteorite has the size, shape, and color of thousands of old olives rotting on the ground. Farmer said he picked up hundreds each day to see if they were meteorites. Moritz Karl

Renowned meteorite dealer Robert Haag has maintained a presence at the Tucson Gem and Mineral Show for several decades. Here, he stands behind the cases he's set up in his room. Haag travels the world in search of space rocks. Michael E. Bakich

more than a decade. Olson has practical advice for newcomers to meteorite collecting: "Go visit museums that have meteorite collections." He suggests looking at known collections so you, as the buyer, have a better understanding of meteorites.

Farmer also encourages new collectors and wants to be sure they understand the market. In fact, he sounds more like an art dealer then a rock hound: "I used to buy meteorites from other dealers only to turn around and throw away their business card." Not any more.

Provenance (the history of past ownership and sales) of a meteorite is becoming important. "A meteorite with a museum tag or number, say from the Nininger collection, will always bring more money," Farmer says.

In promoting meteorite collecting, Farmer has received some unusual international attention. The January 2009 issue of the German edition of *Playboy* featured him in the article "Geld das vom Himmel Fallt" ("Money that Falls From the Sky"). He may have expanded the market because that magazine reaches a readership not usually thinking about rocks from space.

Farmer takes the idea of money from space seriously. He has developed a line of meteorite coins that offers something different for collectors. For $100 or less, you can own a piece of the Moon, Mars, or a meteoritic specimen found in the Sahara Desert, all neatly encased in a coin with descriptions and dates.

Dealers, including Black, Farmer, and Olson, have formed their own internal watchdog group. Recently, an unscrupulous seller who attempted to pass off meteorites with faked origins came to their attention. This core group of dealers quickly noted the scam and just as quickly shut it down. Group members know transparency is best for everyone.

Meteorite dealer and collector Robert Haag displays a new acquisition as he stands before one of the display cases in his house. Michael E. Bakich

Veronica Reyes designs and produces jewelry using meteorites. She collected many of the space rocks herself. Raymond Shubinski

Bud Eisler of Tucson started Cosmic Cutlery, a company that sells meteorites along with knives made from meteoritic iron. Raymond Shubinski

Space-rock party in Tucson

As many of the meteorite dealers gathered for a Friday night party at the Gem Show, the talk, as always, was of space rocks. Longtime meteorite hunter and dealer Robert Haag, of Tucson, chatted with a group of friends about new finds and old adventures. Haag helped fan the recent fire of public interest in meteorite collecting. He also set an example for other dealers by showing a willingness to go anywhere in the world to recover material. To read a profile of Robert Haag, see "Rock star" in the August 2006 issue of *Astronomy*.

Bud Eisler, also of Tucson, has been dealing in meteorites for years. In addition to specimens, Eisler has produced a line of meteorite knives, hence the name of his company, Cosmic Cutlery. Today Bud's son, Joshua, takes care of much of the meteorite business while Eisler pursues new dreams of sunken treasure off the coast of Brazil.

Also at the party was Veronica Reyes, a Brazilian who not only designs and makes jewelry using meteorites, but also is willing to go out to find them herself. She has made a number of trips to the Imilac strewn field in the high desert of Chile to collect specimens for her work.

Darlings of the media

Geoffrey Notkin of Aerolite Meteorites lives in Tucson only a few miles from Haag. Notkin and his friend Steve Arnold, from Arkansas, are longtime partners and have had more than their share of space-rock-related adventures. In 2007, they recovered a massive stony-iron meteorite in Kansas. Like Haag, they have traveled the globe in search of specimens.

Notkin points out, "The Internet changed everything about meteorite collecting." He notes that so many more people now have access to material by going online.

When asked about fakes and outright "meteor-wrongs" that crop up from time to time, Notkin declares, "Many dealers are also collectors, and only a handful make their livelihood full time this way." These dealers don't want fakes on the market because such specimens destroy buyers' trust.

If you want to make sure your specimen is the real thing, join Notkin and Arnold on one of their expeditions. Their team will take you meteorite hunting so you can have the thrill of finding your own piece of outer space.

During a meteorite expedition to McLennan County, Texas, in February 2009, meteorite hunter Geoffrey Notkin's favorite personal find was this triangular individual stone, with a complete blue-black fusion crust. The pointed leading edge is face down, and this piece nearly buried itself in the ground. Geoff Notkin © Aerolite Meteorites

If you prefer an armchair adventure, you can watch for Notkin on the History Channel. That network's 13-part series *How The Earth Was Made* featured him in one episode.

And the Science Channel is working on new episodes of *Meteorite Men*, which detail Notkin and Arnold's adventures. The first episode debuted in May 2009. "Working on meteorite-hunting documentaries for television has become nearly a full-time job," reports Notkin.

Branching out

Even with all of this media attention, the circle of collectors is still rather small. Arnold hopes to change this situation by introducing cosmic gemstones. Pallasites — mixtures of both stone and iron — represent a small percentage of meteorites that reach Earth. These rocks contain olivine, which mineralogists call peridot when the material is of gem quality.

The most beautiful pallasite ever recovered is the Esquel, found in the town of the same name in Argentina in 1951. Jewelers have extracted olivine crystals from this meteorite and turned them into exquisite gemstones.

Recently, Arnold purchased a pallasite whose iron matrix is rather unstable but contains beautiful olivine crystals. Arnold's plan is to introduce cut and faceted gemstones into the mainstream jewelry trade. Perhaps you'll soon meet a bride with a truly cosmic engagement ring.

Your adventure begins

Whatever your interest is in meteorites, plenty of material about the subject exists. As a collector, your job is to become familiar with it and build relationships with the dealers.

Thanks to the Internet, you can access high-quality dealers immediately. You'll find them willing to share their knowledge about these interlopers from space. Meteorite collecting is a field where passion for the subject fuels the fun of collecting.

Raymond Shubinski *is a contributing editor of* Astronomy *and a long-time meteorite collector.*

Meteorite hunter Mike Miller accompanied Geoff Notkin and Steve Arnold on their West Texas meteorite hunt last year. This picture shows him with his largest find. Geoff Notkin © Aerolite Meteorites

Mike Miller, Geoff Notkin, and Steve Arnold found numerous specimens during their West Texas meteorite hunt in 2009. They found this crusted individual at the end of one day's hunting. As Notkin said, "It looked just like a Camel Donga [a stone meteorite found in 1984 in Western Australia], but without the funny accent." Geoff Notkin © Aerolite Meteorites

Learn about the three main types of meteorites at www.Astronomy.com/toc.

Dancing with the galaxies

Target these dozen galaxies with a modest-sized telescope, and you'll find that the Whirlpool is just one shining example of close galaxy pairs. **by Richard Jakiel**

When French astronomer Charles Messier first glimpsed the object he would catalog as M51 in October 1773, apparently he was underwhelmed. He described it in his notes simply: "very faint nebula without stars." As telescopes improved, however, the nebulous object began to take form.

Messier later described M51 as a "double nebula," an impressive feat considering the quality of his small refractor. In 1883, Sir John Herschel saw "a very bright round nucleus surrounded at a distance by a nebulous ring" through his 18-inch telescope.

But the key observation came in the spring of 1845. Using his 72-inch Leviathan of Parsonstown telescope, the Third Earl of Rosse observed the spiral, or "whirlpool," shape of what we now recognize as a spiral galaxy. He sketched not only the spiral structure but also the bridge connecting M51 to its smaller companion. The study of interacting galaxies was born.

Although M51 seemed unique in the 1840s, astronomers have since discovered hundreds of similar pairs. The Whirlpool now serves as the archetype for an entire class of such systems. Any backyard observer with a medium-sized scope and a dark sky can view many of them.

What are the characteristics of an "M51-type system"? First, the main galaxy has to be a spiral. Second, the companion can be no more than 50 percent of the main system's size. And finally, one of the spiral arms must connect with, end at, or at least point in the direction of the smaller system.

Robert Lockwood

Seyfert galaxy NGC 3227 sports a bright nucleus and spiral arms that appear entwined with its elliptical companion, NGC 3226.

Begin with the best

Our tour of a dozen of these systems spans the sky, so you'll have some objects to view any time of year. Let's start with the biggest and brightest: the **Whirlpool Galaxy** (M51) itself. Located in Canes Venatici, it rides high in the evening sky from winter until late summer.

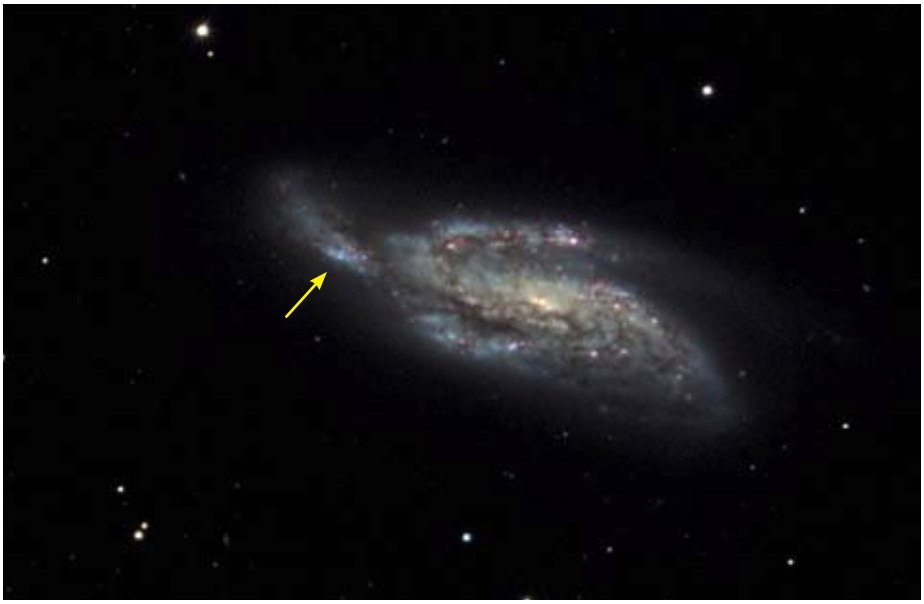
The Whirlpool lies only 30 million light-years from Earth. This makes it the closest example of these objects and a key reason it appears so big and bright. M51 belongs to a small galaxy group that also includes M63.

Through a medium-sized telescope at a good dark-sky site, M51's well-defined, symmetrical spiral arms stand out. The bridge connecting M51 to its companion galaxy, NGC 5195, is harder to see, but observers have spotted it using scopes with apertures as small as 4 inches. Even a small scope reveals the distorted companion. In a large telescope, the view is spectacular. The Whirlpool's arms resolve into several dark rifts and the bright emission regions that give birth to new stars.

The graceful spiral arms of NGC 3893 highlight this Whirlpool system, which includes companion galaxy NGC 3896 southeast (lower left) of the bright spiral. Bob Uminski and Cyndi Kristopeit/Adam Block/NOAO/AURA/NSF

Longtime contributor **Richard Jakiel** *has observed the deep sky for 30 years. His most recent article was "Your scope and the seven dwarfs" (August 2008).*

The Whirlpool Galaxy (M51) is a large spiral interacting with a much smaller one, NGC 5195 (above). This pair is the archetype for systems that feature one large spiral and a companion no more than half as large. Tony Hallas



Bonnie Fisher and Mike Shade/Adam Block/NOAO/AURA/NSF

The distorted spiral NGC 4088 appears to be an M51-type system, although astronomers aren't sure. The apparent companion (arrow) may be a giant emission nebula instead of a galaxy.

Spring's other wonders

M51 may be the finest example of a Whirlpool system, but it's far from the only one. You can find our next target 8° northwest of the Beehive star cluster (M44) in Cancer. The peculiar pair **NGC 2535–6** features a 13th-magnitude spiral galaxy (NGC 2535) with long, tidally extended arms. A burst of star formation wracks the smaller, 14th-magnitude companion (NGC 2536).

You'll need at least an 8-inch telescope and a dark sky to see this pair. Owners of large instruments might detect the main galaxy's faint tidal arms under excellent conditions. Photographs reveal the larger member to be an "ocular" galaxy, meaning its inner structure bears considerable resemblance to the human eye. The pair's interaction creates this shape, which won't survive for a long time.

Our next three systems lie within the confines of Leo the Lion. By far the most impressive is the compact, high-surface-brightness pair cataloged as **NGC 3226–7**. You can find it by looking 50' due east of Algieba (Gamma [γ] Leonis). The main galaxy (NGC 3227) has an active nucleus that classifies it as a Seyfert galaxy. It shines at 10th magnitude and tilts to our line of sight. The elliptical companion galaxy (NGC 3226) appears slightly fainter. It barely falls below the 50 percent size threshold that qualifies this as a Whirlpool system.

At the eastern end of Leo, not far from the Lion's tail star, Denebola (Beta [β] Leonis), lies **NGC 3799–800**. This pair consists of two spiral galaxies. The larger one (NGC 3800) glows at magnitude 12.7 and tilts steeply to our line of sight. The tiny barred spiral companion appears nearly face-on.

Swing your telescope some 7° to the north, and you'll land on **NGC 3808** and **NGC 3808A**. These two galaxies lie more than 300 million light-years from Earth and represent the most remote pair in our sample. The 13th-magnitude main galaxy appears to be a run-of-the-mill spiral oriented face-on to our line of sight, but the smaller system belongs to the rare class of polar ring galaxies. The gravitational interaction between these galaxies has pulled a bridge of stars and gas that stretches more than 75,000 light-years from the main system and wraps around the smaller, distorted one.

Springing into summer

Our next two objects lie just south of the Big Dipper's bowl, which makes them prime targets for viewing on spring and summer evenings. Both systems belong to the southern section of the Ursa Major galaxy group. The first is **NGC 3893/96**. NGC 3893 shows two well-defined spiral arms and a bright core. The secondary galaxy lies 3' southeast of the main one's southern arm. Shining at magnitudes 10.5 and 12.9, these two rank among the brighter pairs in our sample.

The case for including **NGC 4088** as a Whirlpool system is not so clear-cut. This bright, distorted spiral galaxy has prominent arms and a "companion," but astronomers haven't confirmed what this companion is. It appears as a large knot just northeast of the main southern arm. Some interpret it as a secondary galaxy; others think it's a giant emission region within NGC 4088. The radial velocities of the two differ significantly, however, which supports the idea of the object being a separate galaxy. Whatever the case, take time to observe this pretty system. It has a fairly high surface-brightness and takes magnification well. In my 17.5-inch telescope, I can clearly see the spiral arms under good conditions.

About 25° to the southeast of NGC 4088, in Canes Venatici, you'll find the **NGC 5394–5** pair. Some observers call this the Heron Galaxy because it resembles a great blue heron spearing a small fish. The Whirlpool-type system lies 160

A dozen Whirlpool systems

Name	R.A.	Dec.	Mag.	Size
NGC 1347	3h29.7m	–22°17'	13.2/15.3	1.7' by 1.3'
NGC 1531–2	4h12.0m	–32°53'	9.8/12.5	13' by 3'/1' by 1'
NGC 2535–6	8h11.2m	25°12'	12.8/14.1	2' by 1'/1' by 0.5'
NGC 3226–7	10h23.5m	19°52'	10.3/11.4	4' by 4'/3' by 2'
NGC 3799–800	11h40.2m	15°21'	12.7/13.9	2' by 1'/0.7' by 0.4'
NGC 3808–08A	11h40.7m	22°26'	13.4/14.6	1.7' by 0.9'/0.7' by 0.3'
NGC 3893/6	11h48.6m	48°43'	10.5/12.9	5' by 3'/4' by 1'
NGC 4088	12h05.6m	50°32'	10.6/14.5	6' by 2'/0.5'
M51/NGC 5195	13h29.9m	47°14'	8.4/9.5	11' by 7'/6' by 5'
NGC 5394–5	13h58.6m	37°25'	11.4/13.0	3' by 2'/2' by 1'
NGC 7714–5	23h36.4m	2°09'	12.5/14.2	1.9' by 1.4'/2.6' by 0.5'
NGC 7752–3	23h47.1m	29°29'	12.0/14.3	3.3' by 2.1'/0.7'

R.A.=Right ascension (2000.0); Dec.=Declination (2000.0); Mag.=Apparent magnitude.

The Heron Galaxy boasts a large spiral (NGC 5395) interacting with a smaller one (NGC 5394). The former marks the heron's body and the latter, with its open arms, the head and neck. The heron appears to be spearing a "fish" formed by an edge-on background galaxy. Adam Block/Mount Lemmon SkyCenter/University of Arizona

The galaxy pair NGC 7714–5 lies just 3' north of the 6th-magnitude foreground star 16 Piscium. For the best look, place the star just outside the field of view. Adam Block/NOAO/AURA/NSF

million light-years from Earth; a background galaxy located more than 600 million light-years away represents the "fish." A tilted spiral galaxy (NGC 5395) forms the heron's body. A small barred spiral (NGC 5394) with loosely wound arms creates the neck and head. I've observed both galaxies with my 12-inch telescope under decent suburban skies. You'll need a much larger scope to detect the tiny 16.5-magnitude fish.

Treats for longer nights

Our next two systems call the autumn sky home. The highly distorted pair **NGC 7714–5** in Pisces looks impressive visually. However, it lies only 3' north of the 6th-magnitude star 16 Piscium, which makes this object tricky to observe. The best views come if you use higher magnifications and place the star just outside the field.

These two galaxies made a close pass by each other between 100 and 200 million years ago. The encounter triggered a burst of star formation in the larger galaxy (NGC 7714). In my 17.5-inch scope, this galaxy shows a bright, well-defined core while its companion appears much more elongated and diffuse.

From a distance of 200 million light-years, **NGC 7752–3** looks like a clone of M51. It lies just north of the Great Square of Pegasus, some 5° due west of Alpheratz (Alpha [α] Andromedae). Moderate telescopes reveal the bright core and oval shape of the main galaxy (NGC 7753) as well as the smaller, diffuse companion. Using a 24-inch telescope under a dark sky, this pair resembles M51 as seen through a 4- to 6-inch scope. I can see the bright oval core and traces of spiral structure but not the connecting bridge.

Long winter nights are perfect times to track down our final two Whirlpool systems. Eridanus hosts **NGC 1347**, a 13th-magnitude barred spiral with a 15th-magnitude companion. It lies 1° southwest of 4th-magnitude Tau^5 (τ^5) Eridani. Use an 8-inch or larger scope and medium power to find this elusive object.

The **NGC 1531–2** pair looks more impressive through the eyepiece. A huge edge-on version of M51, it lies on the outskirts of the Fornax galaxy cluster some 55 million light-years from Earth. This would be a showpiece object if the pair weren't so far south. It lies in the middle section of Eridanus the River, about 1.5° northwest of 4th-magnitude Upsilon^4 (υ^4) Eridani.

The barred spiral NGC 1532 shines at magnitude 9.8 and spans 13'. This makes it roughly twice the physical size of M51. The companion (NGC 1531) is a dwarf lenticular galaxy that lies at the end of the main galaxy's western arm. A medium-sized telescope shows NGC 1532's edge-on nature and dust lane as well as the companion galaxy. Larger scopes reveal several satellite galaxies.

We have only scratched the surface of these amazing Whirlpool systems. If they whet your observing appetite, the best source for more targets is "A Catalog of M51 Galaxy Associations" (visit the web site jorcat.com). The catalog contains 232 M51-type galaxy pairs. Dozens of these fall within range of moderate-sized telescopes, and astroimagers can photograph plenty more. You'll find enough objects to keep you satisfied for many nights.

Explore Scientific's 5-inch APO combines power and portability

High-quality optics and craftsmanship make this a telescope you'll be proud to own. **by Mike Reynolds**

This apochromatic refractor comes with a 99 percent reflective dielectric star diagonal. This slides into a Crayford-style two-speed focuser.

I'll admit it: I love apochromatic (APO) refractors. Although I grew up using reflectors, I have developed an appreciation for the image through a high-quality APO. So when a new one appears, it catches my interest.

Explore Scientific, based in Laguna Hills, California, introduced its APO series at the 2009 Winter Star Party. I was eager to look through them there, and when the opportunity to evaluate the 127mm (5-inch) f/7.5 Air-Spaced Triplet ED APO arose, I jumped at it.

Contact information

Explore Scientific
22 Sparrow Hill Lane
Laguna Hills, California 92653
[t] 888.599.7597
[w] www.explorescientific.com

First impressions

As I removed the optical tube assembly from its case, I marveled at this well-built instrument. The tube has a beautiful white-gloss finish. The company's new design of the dew shield makes it fully functional and removable.

The focuser is a high-quality, two-speed 2" Crayford style with a 10-to-1 reduction for the slower speed. The focuser features an engraved calibrated scale. The focuser operated smoothly. It easily held a combination of my digital SLR and Barlow lens without any slipping or flexing. A universal dovetail mounting plate cradles the optical tube assembly. A carrying handle on the opposite side of the plate also makes a great feature.

When inspecting any refractor, I look through the front lens down the tube. It may look strange, but I do that to check out the internal baffling. I then back off a bit to view the overall appearance of the lens. The 127mm ED APO's baffling is significant and well-made. And the objective, a true three-lens APO that uses extra-low dispersion glass developed by Hoya Optical of Japan, is of high-quality construction. Explore Scientific has engineered the lens cell so you can collimate it (realign it to achieve optical centering) if it ever gets misaligned.

The 127mm ED APO includes an 8x50 erect image finder scope. This finder's design is one of the most useful I've seen. It provides an erect image, and Explore Scientific's designers came up with a new crosshair pattern. What you see is not the traditional "+" crosshairs but an illuminated reticle with circles

Mike Reynolds *is a contributing editor of* Astronomy *and dean of Liberal Arts and Sciences at Florida State College at Jacksonville.*

Explore Scientific's 127mm f/7.5 Air-Spaced Triplet ED APO features a well-thought-out design that includes a carrying handle.

All photos: *Astronomy*: William Zuback

Product specifications

Type: Apochromatic refractor
Aperture: 5 inches (127 millimeters)
Objective: Three-element air-spaced triplet lens
Focal length: 952mm
Focal ratio: f/7.5
Shipping weight: 55 pounds (24.9 kilograms)
Also comes with: Cradle rings with handle and universal dovetail mount saddle plate, a removable dew shield, front and rear dust covers, a Crayford-style two-speed (10:1) focuser, a 2" 99 percent reflective dielectric star diagonal, an 8x50 finder scope with an illuminated-reticle viewfinder, and a deluxe heavy-duty case
Price: $1,999

having diameters of 1.5°, 3°, and 4.5°. The edge of the field marks a 6° circle.

Under the sky

A series of clear nights enabled me to put this telescope through its paces. I was not disappointed. Turning the 127mm ED APO to a First Quarter Moon provided exceptionally sharp images. I first used a 26mm eyepiece, which yielded a magnification of about 37x.

The night was a good one, so I pushed the magnification up, first with a 12mm eyepiece (79x), then a 6mm eyepiece (159x). All the images appeared crisp. Later, I took advantage of the steady night and used a 4x telecentric Barlow lens with the 12mm eyepiece. This gave me a magnification of 317x, quite a bit beyond the oft-quoted upper magnifying limit of 2x per millimeter of aperture. Lunar views remained excellent.

I turned the telescope toward Saturn, and I noticed how the finder scope, with its erect image and open crosshair design, made centering every object easy. The planet was spectacular at a variety of magnifications. The subtle equatorial belts were easily visible, and the rings, even though they approached their edge-on orientation, were sharp.

The finder scope on the 127mm ED APO features an illuminated-reticle viewfinder with three circles that mark different fields of view. The finder scope mount has a six-point alignment system.

While observing stars, I first noted the pinpoint images I saw all the way across the field of view, regardless of the magnification. Diffraction rings produced by the 127mm ED APO were textbook. I viewed bright stars (such as Betelgeuse and Sirius), faint ones, and numerous double stars (like Rigel and Castor). All of them displayed superb contrast and the correct colors. The background appeared velvet black throughout to the edge of the field of view.

I spent lots of time observing deep-sky objects. I wended my way from open clusters such as the Pleiades (M45) to nebulae like the magnificent Orion Nebula (M42) to a number of galaxies. In particular, the Andromeda Galaxy (M31) was stunning. The 127mm ED APO gave me a view as large as the one I can see through large high-quality binoculars, but with details I've caught only through a large telescope. Through low-power (wide-field) eyepieces, I especially enjoyed the Sailboat Cluster (Harrington 6) in Leo Minor and the Coma Berenices star cluster (Melotte 111). I was not disappointed in any way.

My final test on any refractor is the Full Moon, which provides one of the best chromatic aberration tests. Chromatic aberration usually shows up as color fringing around bright objects, and the Full Moon is as bright as it gets. When it comes to color, the quality of the lens cannot hide under the light of the Full Moon. The 127mm ED APO did not show a hint of color when I focused the image nor when it was out of focus.

The objective lens is a three-element air-spaced triplet that uses low-dispersion glass. It has a focal ratio of f/7.5.

The Explore Scientific 127mm f/7.5 Air-Spaced Triplet ED APO comes with a standard 1-year limited warranty that you can extend to 5 years by completing and mailing the product registration card within 60 days. Overall, the telescope represents a great value. Explore Scientific produced a good design and added high-quality optics to match.

Observing Basics

by Glenn Chaple

Astroimaging 101

An "old-timer" makes his first attempts at digital astrophotography.

This column traces its roots to the January 2002 issue of *Astronomy*. Under the name "Beginner's Sky: Diary of a neophyte astronomer," author Jerry Burstein chronicled his adventures as a newcomer to backyard astronomy. Upon inheriting Jerry's column, I approached it from a different angle — that of a veteran observer passing on helpful hints to the novice.

This month, however, I'll take a page from Jerry's book and relate my adventures as a novice attempting something completely alien to me: digital astrophotography. As an "old-timer" who prefers sketching at the eyepiece, I'm clueless when it comes to digital cameras, never mind using one to image the night sky! So, with a nod to Jerry Burstein, I'd like to share with you my version of "Diary of a neophyte astronomer."

***March 16, 2009:* The Inspiration**

Norwegian amateur astronomer Per Hauger sends an e-mail that includes photos of the Moon, the Big Dipper, and Orion taken with an inexpensive digital camera. His message is that basic digital astrophotography is a relatively easy process. "Might be worth a try," I think.

***Aug. 13, 2009:* Beginnings**

I've arranged with friend Bill Pothier to take daylight photos through my 4.5-inch reflector using his digital camera. I'm applying two beginner's tactics: 1) work by day to see what you're doing; and 2) team up with someone who can help you.

I try photographing a block and tackle on Bill's barn while hand-holding his camera to the eyepiece. Not an easy task — my hands aren't very steady! Bill clamps a camera holder to the eyepiece.

Browse the "Observing Basics" archive at www.Astronomy.com/Chaple.

The author captured this image of a waxing gibbous Moon August 30, 2009. He used a Canon PowerShot A640 with Orion Skyquest 4.5-inch reflector. Glenn Chaple

Ah! This is more like it. Later, Bill e-mails me the results. Not great, but it's a start.

***Aug. 19, 2009:* Constellation Shots**

My attempt at imaging constellations is doomed from the start. Bill knows how to take daytime pictures, but nighttime photos are a different matter. His camera can't take the time exposures needed to capture a constellation.

***Aug. 27, 2009:* Clouded Out!**

Bill and I decide to move on to the Moon, currently at First Quarter phase — a great photo op! During the 10-minute drive to Bill's home, clouds move in. When it comes to weather, astrophotographers have no more luck than the rest of the astronomical community.

***Aug. 30, 2009:* The Moon and Beyond**

Bill borrows a digital camera from a neighbor, who bought it used for $150. We turn to the Moon, now at waxing gibbous phase. A series of shots yields good results, especially at low power.

Because this camera can take time exposures, Bill and I decide to try imaging a constellation. We opt for Cassiopeia, framed nicely by nearby trees. After setting the f-stop (which regulates how much light passes through the lens by varying the size of the hole the light comes through) as wide open as possible, we take a set of images. We experiment with the ISO settings (which dictate how sensitive the image sensor is to the light) as well as the exposure times. Bill e-mails the best photos from the session. The Moon shots look pretty good, but moonlight has washed out the Cassiopeia photo.

Overall, it's been a good introduction to basic digital astrophotography. Hauger was right — it's relatively easy.

***Aug. 31, 2009:* What I Learned**

Digital cameras are the way to go. Not only do you get immediate results, but the camera's memory card also allows for many more shots than the traditional roll of 35mm film.

Hand-holding a camera to a telescope while taking a picture is difficult. A camera holder (which costs around $50) solves the problem.

Eyepieces with a high degree of eye relief work best. Otherwise, the camera view will suffer from vignetting — a condition where the field of view is reduced to a small circle.

The weight of the camera and holder may cause the telescope tube to drop. A supporting hand or a counterweight helps.

Now it's your turn. If you own a digital camera and know how to use it, you're halfway there! Go outside and give it a try. Who knows — someday one of your astrophotos might make the "Reader Gallery" at the back of an issue of *Astronomy*! And in the meantime, you can always post your photos online at www.Astronomy.com/readergallery.

Questions, comments, or suggestions? E-mail me at gchaple@hotmail.com. Next month: Astroimaging my way (get out your pencil and sketch pad). Clear skies!

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Evening Stars
by David H. Levy

One world, one sky

Observing in other regions can be different from what you're used to, but you might be surprised at the similarities.

Do you ever wonder if your first days in astronomy would have been different if you had lived in a different country? The answer would be, of course, yes! In fact, your observing experiences would have changed even if you lived across the street. Although the sky is virtually the same throughout the Northern Hemisphere, each of us has an exclusive way of enjoying it.

This month we meet Pakistani Tahir Iqbal Gadhoka and learn about his way of enjoying astronomy. His story demonstrates that when it comes to the sky, we don't have warring countries or opposing religious views; we just have one world and one sky. This young man comes from, as he puts it, "that part of the world where only a few folks are aware of the night sky and admire it." Tahir is trying to change that.

He was born December 16, 1984, just a month after my first comet discovery. "While studying in school, I'd watch space-related movies," he says. "I was so obsessed with extraterrestrials! … People just laughed at my ideas because I used to draw alien figures on the blackboard."

The huge city of Lahore, Pakistan, shines brightly at night, so observers like Tahir must go elsewhere for their dark-sky fix. ©iStockphoto.com/maxloxton

Tahir Iqbal Gadhoka, a native of Pakistan, has enjoyed amateur astronomy ever since spotting Comet Hyakutake in 1996. Tahir Iqbal Gadhoka

Even his parents would grow tired of his sci-fi obsessions, he says. But these "silly" childhood fantasies evolved into a serious interest in astronomy. After completing Qaumi Foundation High School, Tahir studied commerce briefly at Hajvery University in Lahore, Pakistan. He still lives in Lahore, the country's second-largest city and the fifth largest in South Asia, with a population of more than 10 million.

In the nearby small town of Usman Kot, with just over 100,000 inhabitants, the sky is far darker and "crystal clear," Tahir says, and he observes from there. His observing passion began in 1996 with Comet Hyakutake. "I was sitting with my family and listening to CNN when the news of Comet Hyakutake was broken," he says. "I remember that night, when my uncle took me to his room and showed me that comet towards the north." Tahir also recalls spotting a bright meteor one morning, heading north during twilight. Like many of us who started by ourselves, Tahir didn't need any astronomy courses. He began just by looking to the sky, observing a comet and a fireball, and never stopped. He currently uses a 1.6-inch (40mm) refractor equipped with a 13–40x zoom eyepiece.

Although Pakistan may not be the ideal place to begin a career as an observer, the country does offer high mountains and a clear sky. Tahir says it's so perfect that "when I am not using a telescope, I prefer to lay on the ground and look at the entire sky to enjoy meteor showers and hope to see fireballs." To study sunspots, he projects the Sun's image into an empty shoebox.

I hope Tahir continues to enjoy the night sky. He is a leading example of what I want to see more of: a person with his head in the clouds but his feet on the ground. Thanks to some good mentoring from teachers like Muntazir Mehdi, who encouraged his interests, Tahir has become quite skilled at finding his way around the sky. I hope someday he will be able to expand his observing interests with a better telescope, as well as inspire others to take up astronomy not necessarily as a career, but as a happy activity.

The sky is one of the few things common to every land on Earth. From a country far across the sea, this wisdom reminds us that we can all reach for the stars.

Browse the "Evening Stars" archive at www.Astronomy.com/Levy.

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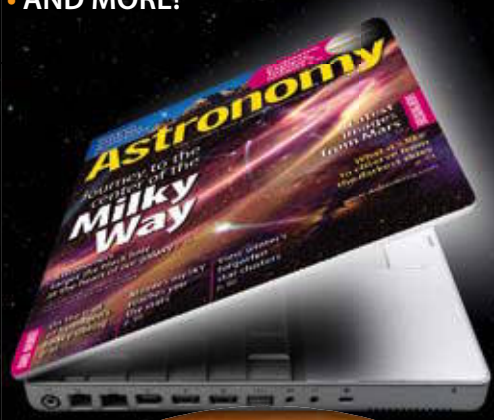

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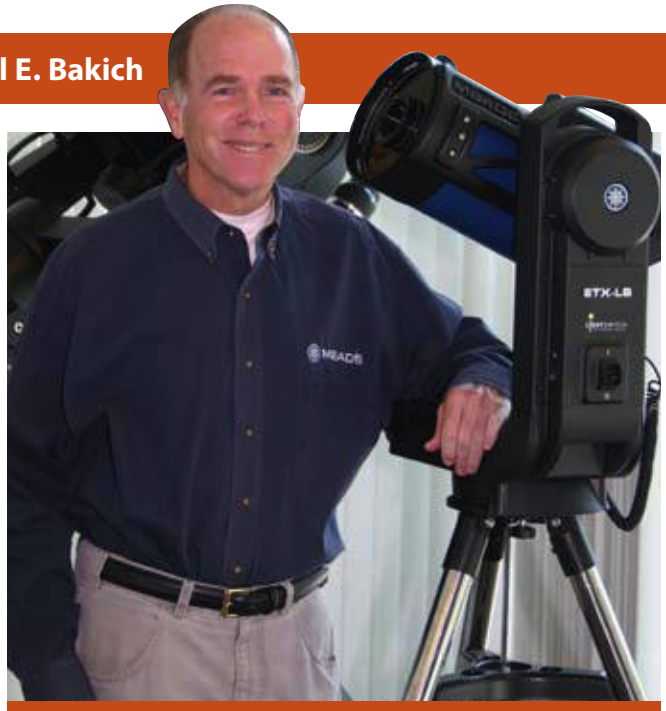
CIR-ADH-09X1016RH

by Michael E. Bakich

Steve **Murdoch**

Chief Executive Officer/Director, Meade Instruments



Steve Murdoch shows off Meade's newest entry: the LS6 with LightSwitch™ Technology. Courtesy Meade Instruments

Steve Murdoch is California through and through. He was born in Glendale, which lies about an hour's drive from his current office at Meade Instruments in Irvine. He graduated from California State University at Northridge with a Bachelor of Science degree in business administration.

Before moving to Meade, Murdoch served as the optics manager at Coulter Optical in North Hollywood for 11½ years. He started with Meade as the company's vice president of optics in May 1980. At that time, the company was only in its ninth year of operation.

Through the years, he's been Meade's president and chief operation officer, and director. Finally, in February 2009, he became chief executive officer/director.

"Amateur astronomy competes with consumer electronics to capture and keep the attention of the public. We need to supplement the experience of observing, therefore, with relevant, informative, and entertaining media that are quickly and easily accessible."

Tell us about Meade's most popular models.

Meade Instruments offers a wide range of telescopes and accessories, starting with a basic instrument that costs only $50, all the way to our most advanced model at $35,000.

Two particular series of telescopes come to mind: the LX200 and our new LS.

The LX200-ACF series features truly outstanding telescopes. We offer them in 8-, 10-, 12-, 14-, and 16-inch apertures. Each has imaging capabilities and features that stand above other telescopes.

Meade engineers developed a radical new Advanced Coma Free (ACF) design by combining a hyperbolic secondary mirror with a corrector lens and a spherical primary mirror. This combination performs like one hyperbolic element.

The ACF series produces a coma-free, flat field of view that rivals Ritchey-Chrétien (RC) telescopes at a fraction of the cost. Our ACF design eliminates diffraction spikes and lessens the problem of astigmatism, both of which are inherent in the traditional RC design.

Our newest product, the LS6 with LightSwitch™ Technology, aligns itself at the flip of a switch. In addition to the 6-inch telescope, drive, and mount, the package comes complete with audio and video content. It really is amazing to watch this telescope auto-align.

Tell me something cool about Meade.

Meade Instruments not only makes high-quality optics for telescopes, but we also produce digital imagers for advanced medical devices that sell for tens of thousands of dollars.

How has Meade changed through the years?

Actually, not much. Meade Instruments has always been a dynamic organization, with growth and innovation at its core. My plan is to focus on product development, customer service, and quality.

Do you enjoy observing? Anything specific?

To be quite honest with you, I like making telescopes. I began 40 years ago as the optics manager for Coulter Optical, Inc. and joined Meade Instruments in 1980. I enjoy observing but would not call myself an avid amateur astronomer.

Can you share anything about upcoming products?

We have many new products in the works. We are currently working on a new digital camera for the LS series telescopes.

Where, in your opinion, is the hobby headed?

I think the entry-level portion of the hobby is moving to include more audio and video content into the viewing experience.

Amateur astronomy competes with consumer electronics to capture and keep the attention of the public. We need to supplement the experience of observing, therefore, with relevant, informative, and entertaining media that are quickly and easily accessible. I think that our LightSwitch™ Technology family of telescopes includes products that will address that need.

New Products

6-inch StarBlast

Orion Telescopes and Binoculars
Watsonville, California

Orion's StarBlast 6i IntelliScope Reflector incorporates Orion's IntelliScope technology, which gives observers a database of 14,000 objects. The f/5 StarBlast 6i ships with a fully assembled base and weighs 23.5 pounds (10.7 kilograms).

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80mm refractor

Orion Telescopes and Binoculars
Watsonville, California

Orion's GoScope 80mm Refractor Telescope offers 3.15 inches of aperture. The tube assembly attaches to a tabletop base via a quick-release dovetail. Orion includes two eyepieces, a 45° correct-image diagonal, and a red-dot finder.
Price: $99.95
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Motorized focuser

JMI Telescopes
Lakewood, Colorado

JMI's Motofocus for the Meade ETX LightSwitch 6 provides precise focusing. A user can install the device quickly. It uses either power from the telescope or from a JMI hand unit. The telescope can point to the zenith with the focuser installed.

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Machesney Park, Illinois

Astro-Physics' Celestron-SCT-to-AP 2.7"-Thread Adapter allows you to use Astro-Physics 2.7" accessories with 11-inch or 14-inch Celestron Schmidt-Cassegrain telescopes. The adapter is machined aluminum and anodized black.
Price: $60
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Star diagonal

ISTAR Optical
Page, Arizona

ISTAR Optical's 2" diagonal combines an aluminum housing with a hardened chrome-plated nosepiece. The mirror is 0.5 inch (12mm) thick and has 40 layers of dielectric coating for 99 percent reflectivity. ISTAR threaded the barrel for 2" filters.

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The Universe in Blu-ray

The History Channel
New York, New York

The History Channel has released season one of its hit series *The Universe* as a set of three Blu-ray disks. The set has all 13 episodes, including "Life and Death of a Star," "Secrets of the Sun," and "Beyond the Big Bang." Programs appear in 1080p resolution.
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Elements of the Universe poster

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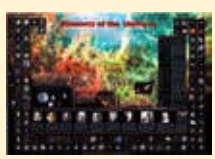
Dubuque, Iowa



Jensan Scientifics offers a 26.5 inches tall by 38 inches wide (67.3 by 96.5 centimeters) poster of the universe's elements. The laminated chart has information about the early universe plus photos of astronomers and Messier objects.
Price: $23.95
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The Cosmic Grid

All things high, low, weird, and wonderful in astronomy and space science. **by Bill Andrews and Liz Kruesi**

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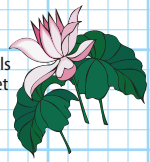
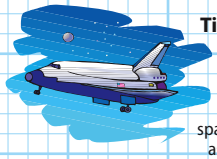
Dust free

NASA develops self-cleaning materials based on the lotus plant. No word yet on Venus flytrap-based weapons.





Tinkle, tinkle little star

Skygazers treated to a bright sparkling glow were, in fact, observing astronaut urine leave the space shuttle. Man, everything astronauts do is impressive!

Dark matter specs

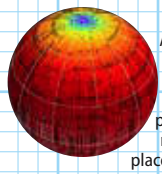
European researchers develop a "scintillating bolometer" to try to detect dark matter. Looks like the steam punk look is big in Europe, too.

IYA currency

Romania, Canada, Australia, and Malaysia all mint special IYA-inspired coins. We look forward to the inevitable Astronomy Standard.

Martian models

New model allows scientists to "Reconstruct Mars automatically in minutes!" Batteries, life not included.



Lunar chill

Antarctica's got nothing on permanently shadowed regions at the Moon's south pole. These regions just might be the coldest places in the solar system, at a nippy 35 kelvins.

Funny side of NASA

NASA sneaks in a fake news release detailing the Jon Stewart/Stephen Colbert feud; never before has a treadmill wrought such hate amongst TV hosts.

1 down, 65 to go

Telescope operators with the Atacama Large Millimeter/submillimeter Array bring the first 12-meter diameter antenna to its 5,000-meter-high observing site in the Chilean Andes.

Spacey legislators

The state of Illinois passes a resolution stating that "as Pluto passes overhead through Illinois' night skies, that it be reestablished with full planetary status." However, the City of Chicago may charge a toll.

Cosmic high

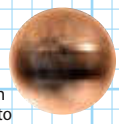
NASA says galactic cosmic rays have just hit a high, making manned missions potentially more hazardous. But could it make their urine even more glorious?

Go Ray!

Contributing Editor Ray Jayawardhana, an astronomer at the University of Toronto, is named to Caldwell Partners' Canada's Top 40 Under 40 for the second year in a row.

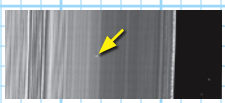
Adding insult

The International Astronomical Union reconfirms its definition of a planet, keeping Pluto a mere "dwarf planet." Not very big of them.



Hubble's back!

The Hubble Space Telescope works again! The world's most famous scientific instrument returns to its job of making us go "ooh."



New moon

Another moonlet discovered in Saturn's rings during its equinox, when the rings face us nearly edge-on, affords scientists another opportunity to say "moonlet."

Fly me through the sky

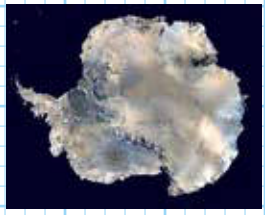
European Southern Observatory releases GigaGalaxy Zoom on the Internet, showcasing the sky (and zoomed-in regions) and providing another reason to sit on the couch and surf the Web.

E.T. math

A new equation, dubbed the "habitability index," could do for planet habitability what the Drake Equation did for intelligent life. Future T-shirt designs still incomplete.

Why the Moon shines

NASA's Lunar Reconnaissance Orbiter finds widespread water on the Moon. That's good news for future lunar astronauts who don't like bottled water.



Looking for a homesite?

The best place to build an observatory stands 4,053 meters high on the Antarctic Plateau. The weather forecast? Clear, sunny, and 94° F (below zero).

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1. Publication title: ASTRONOMY
2. Publication No.: 531-350
3. Filing date: October 1, 2009
4. Issue frequency: monthly
5. Number of issues published annually: 12
6. Annual subscription price: $42.95
7. Complete mailing address of known office of publication: 21027 Crossroads Circle, Waukesha, WI 53186
8. Complete mailing address of headquarters or general business office of publisher: same
9. Publisher: Kevin P. Keefe, 21027 Crossroads Circle, Waukesha, WI 53186. Editor: David J. Eicher, same. Executive Editor: Dick McNally, same.
10. Owner: Kalmbach Publishing Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187-1612. Stockholders owning or holding 1 percent or more of total amount of stock are: Gerald & Patricia Boettcher Living Trust, 8041 Warren Ave., Wauwatosa, WI 53213; William & Mary Calhoun Jr., 1706 Ptarmigan Trail #205, Estes Park, CO 80517-9757; Ruth H. O. Darragh, 1200 W. 3rd St., Waterloo, IA 50701; Melanie Duval, 8642 Bronson Dr., Granite Bay, CA 95746-9313; Harold Edmonson, 6021 N. Marmora Ave., Chicago, IL 60646-3903; Laura & Gregory Felzer Jt. Tenants, 220 E. Michigan St., Suite 10, Milwaukee, WI 53202; Susan E. Fisher Revocable Trust, 6244 N. Ventana View Pl., Tucson, AZ 85750-0705; George A. Gloff, c/o Ted & Lois Stuart, 1873 Frays Mill Rd., Ruckersville, VA 22968; Elizabeth K. Grunden, 14102 Seagler Springs Lane, Houston, TX 77044; Linda H. Hanson, 363G Bateman Circle S., Barrington Hills, IL 60010; George F. Hirschmann Trust, 363G Bateman Circle S., Barrington Hills, IL 60010; James & Carol Ingles, P. O. Box 2161, Waukesha, WI 53187; Charles & Lois Kalmbach, 7435 N. Braeburn Lane, Glendale, WI 53209; Kalmbach Profit Sharing/401K Savings Plan & Trust, P. O. Box 1612, Waukesha, WI 53187-1612; James & Elizabeth King, 3874 Quail Ridge Dr., Boynton Beach, FL 33436; Mahnke Family Ltd. Partnership/Trust, 1979 Discovery Village Lane, Gold River, CA 95670-7279; George Steven Mahnke, 4708 Olive Oak Way, Carmichael, CA 95608; Mundschau Revocable Trusts, N24 W30420 Crystal Springs Dr., Pewaukee, WI 53072-4275; Daniel & Mary Murphy, 705 Heathery Ln., Naples, FL 34108; Robclif, Inc., P. O. Box 3597, Reno, NV 89505; David M. Thornburgh Trust, 420 W. San Marino Dr., Miami Beach, FL 33139-1136.
11. Known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities: N/A
12. Tax status (for completion by nonprofit organizations authorized to mail at nonprofit rates): N/A
13. Publication title: ASTRONOMY
14. Issue date for circulation data below: September 2009
15. Extent and nature of circulation:

	Average no. copies each issue during preceding 12 months	No. copies of single issue published nearest to filing date
a. Total number of copies (net press run)	177,751	173,665
b. Paid circulation (by mail and outside the mail)		
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The magazine said the *Hot Product for 2009* **AT6RC** 6" f/9 Ritchey-Chrétien, above, was "a superb match" for the APS-C chips used in many DSLR cameras.

About the $1395 **AT8RC** 8" f/8 Ritchey-Chrétien, right (a *Hot Product for 2010* winner, along with the new $2695 **Astro-Tech AT10RC** 10" f/8 Ritchey-Chrétien), the magazine said "it was how nicely this scope is matched to APS-C and 35-mm formats that really wowed me . . . what's not to like?"

AT8RC $1395

AT8IN $449

And the magazine said that the **AT8IN** 8" f/4 imaging Newtonian, shown left, "with its 8-inch aperture and $449 price tag, wins the biggest-bang-for-the-buck award."

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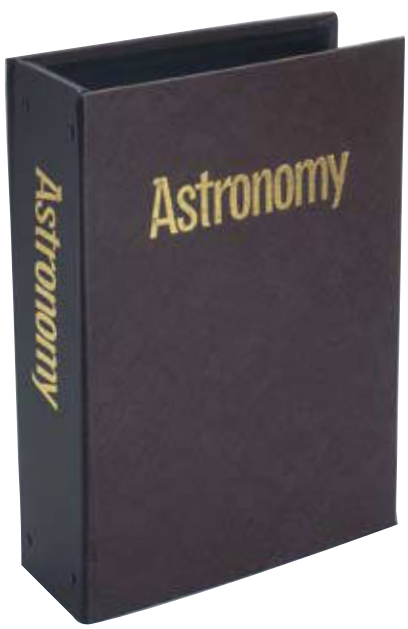

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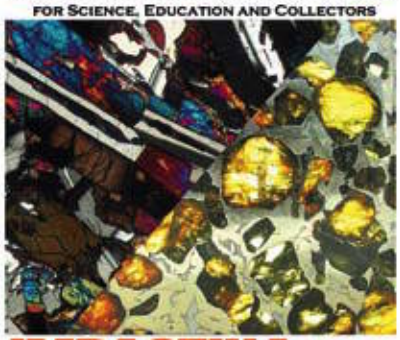

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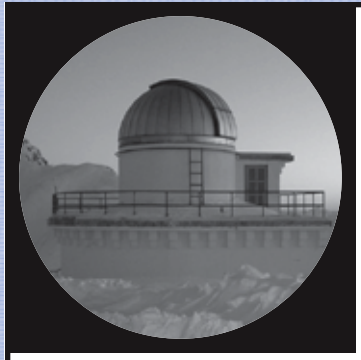

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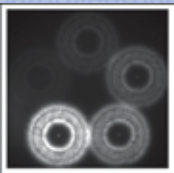

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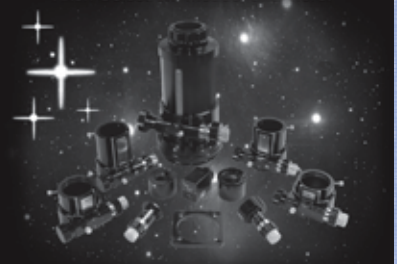

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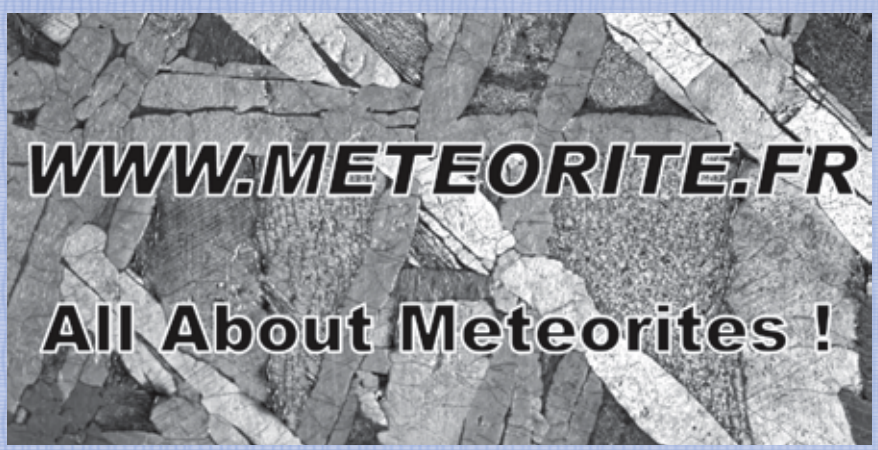
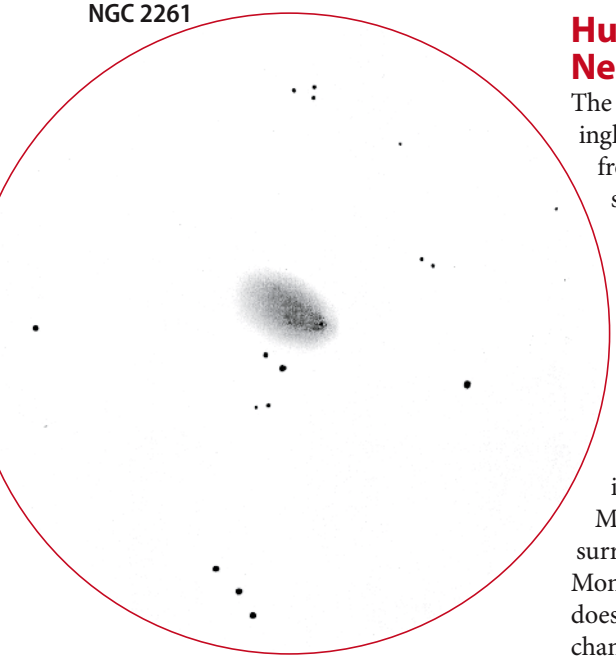


Deep-sky Showcase

Astronomy's *editor sketches two of his favorite objects.* **by David J. Eicher**

Hubble's Variable Nebula and NGC 1535

NGC 2261



Hubble's Variable Nebula sketched by David J. Eicher using a 17.5-inch f/4.5 reflector at 71x.

Hubble's Variable Nebula (NGC 2261)

The stars are so far away, the sky seemingly eternal. Little changes in the sky from night to night, unless it's a planet sneaking past the fabric of background stars that lie in the distance beyond.

Not so! Countless objects are moving and changing in the cosmos constantly — most are just slow-changing and so distant that it's hard to tell. But a bona fide deep-sky object that allows you to see it change over weeks or months is Hubble's Variable Nebula in Monoceros, a wedge-shaped glow that surrounds a variable star. As the star, R Monocerotis, brightens and fades, so does the nebula — and the nebula's shape changes, too.

Through a medium-sized telescope, the nebula appears as a faint triangular glow fanning away from the star, which lies at the triangle's apex. Because Edwin Hubble studied this nebula extensively in the early 20th century, it is now nicknamed after him. Known for some 200 years, the nebula is a complex of emission and reflection nebulosity that spans about 1 light-year.

NGC 2261

Daniel Verschatse

Designation: NGC 2261
Position: 6h39m, 8°45' (2000.0)
Constellation: Monoceros
Magnitude: approximately 9, variable
Size: 2' by 1'
Distance: 2,500 light-years

NGC 1535

Adam Block/NOAO/AURA/NSF

Designation: NGC 1535
Position: 4h14m, –12°44' (2000.0)
Constellation: Eridanus
Magnitude: 9.6
Size: 18"
Distance: 1,500 light-years

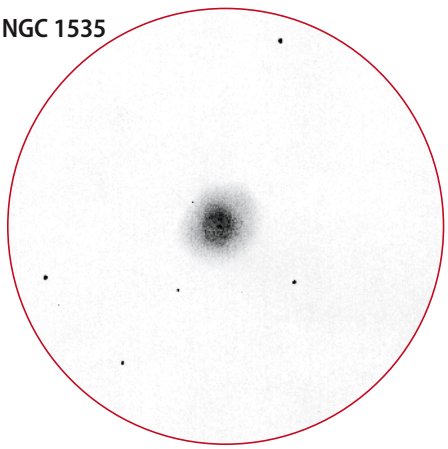
David J. Eicher *is the editor of* Astronomy. *He has observed and sketched deep-sky objects for 33 years.*

Planetary nebula NGC 1535

This nebula represents the result of a Sun-like star that exhausted its nuclear fuel and whose star, in its early death throes, belched out two great spheres of gas. The material glows like a fluorescent light bulb, and it will ultimately recycle back into infant stars from the gravitational collapse of future clouds. For now, its central region appears as an electric-green ball spanning about 18" — surrounded by a faint, older shell of gas measuring some 44" across.

The nebula's central star, the dying sun that powers its glow, is a 12th-magnitude object visible through medium-sized scopes. Using an 8-inch scope at 255x, I find the nebula to be an intense blue-green disk with a faint outer halo; the central star dimly glows inside. It's a nebula with a high surface-brightness, so it can withstand high magnifications well. Observe it, and you may find it added to your list of wintertime favorites.

NGC 1535



NGC 1535 sketched by David J. Eicher using an 8-inch f/10 SCT at 255x.

reader gallery

Thor's Helmet (14.5-inch RC Optical Systems Ritchey-Chrétien telescope at f/9, SBIG STL-11000M CCD camera, HαLRGB image with exposures of 30, 15, 10, 10, and 10 minutes, respectively) • David Plesko (image exposure) and Warren Keller (image processing), Buckhannon, West Virginia

Emission nebula NGC 2467 in Puppis is a breeding ground of new stars. Many hot blue stars here emit ultraviolet radiation that atoms in the cloud absorb and then re-emit as light with a reddish color. (12.5-inch Optical Guidance Systems Ritchey-Chrétien reflector, SBIG ST-10XE CCD camera, HαRGB image with exposures of 266, 30, 30, and 30 minutes, respectively) • Ted Wolfe, Naples, Florida

Behold the thunder god

Thor's Helmet (NGC 2359) — perhaps the most impressive name for any deep-sky object — is a cosmic bubble sculpted by radiation from a type of luminous, massive star called a Wolf-Rayet star. These short-lived supergiant stars are rare; astronomers have discovered fewer than 250 of them within the Milky Way.

As the star enters the Wolf-Rayet stage, a powerful stellar wind of up to 6 million mph (10 million km/h) ejects the star's outer envelope. This gas slams into the surrounding interstellar medium and sculpts a beautiful shocked shell of ionized gas.

The T-rex Nebula (Sharpless 2–157) is a huge ionized hydrogen region in Cassiopeia. It lies on that constellation's border with Cepheus, 1.8° southwest of the magnitude 6.9 open cluster M52. (7.2-inch Takahashi Epsilon 180ED astrographic telescope at f/2.8, SBIG ST-10XME CCD camera, HαRGB image with exposures of 610, 380, 375, and 380 minutes, respectively) • Keith Schlottman, Tucson, Arizona

The Full Moon rises over the Church of Agios Sotirios. The imager shot this scene from a distance of 0.76 mile (1,230 meters) to get the right size ratio. (4-inch Takahashi FSQ-106 refractor at f/5, Canon EOS 5D digital SLR, ISO 100, 1/50-second exposure taken October 4, 2009, at 16h02m26s UT, from Oropos, Greece) • Anthony Ayiomamitis, Athens, Greece

> **Spiral galaxy NGC 4535** in Virgo has well-developed spiral arms defined by blue star clusters and red nebulous regions. This galaxy glows at magnitude 9.8 and measures 7' by 5'. (16-inch RC Optical Systems Ritchey-Chrétien reflector at f/9, SBIG STL-6303M CCD camera, eighteen 20-minute exposures through L, R, G, and B filters, for a total exposure time of 24 hours) • Keith B. Quattrocchi, Clovis, California

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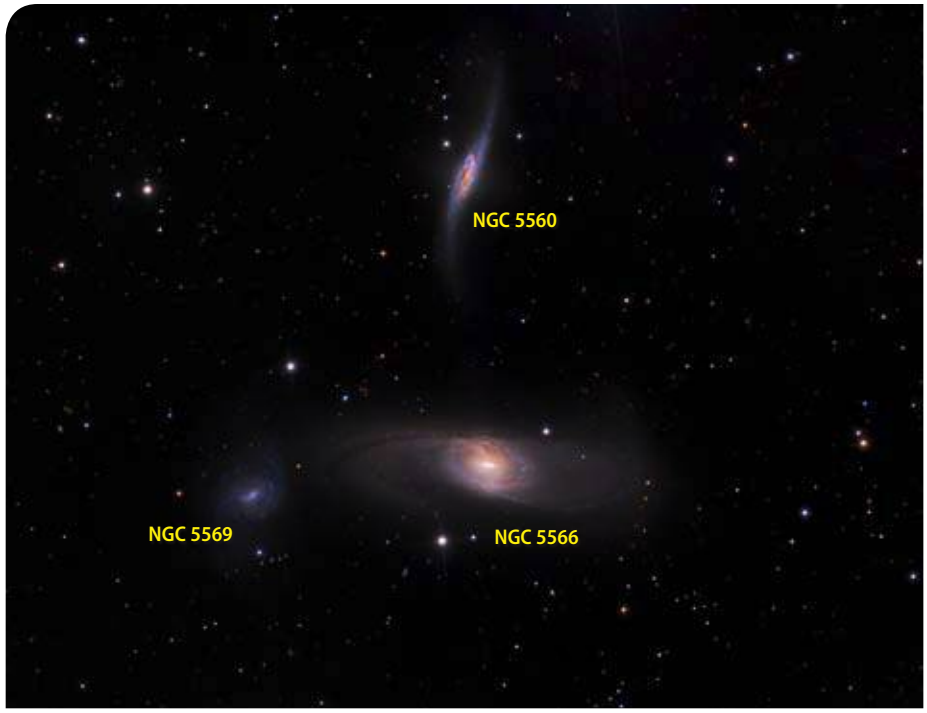

<Mandel-Wilson 9 is an example of an integrated flux nebula. Single stars don't illuminate these gas clouds. Rather, the energy from all the Milky Way's stars causes them to glow. (4-inch Takahashi FSQ-106 refractor at f/5, SBIG STL-11000M CCD camera, 6-panel LRGB mosaic with each panel having 2 hours of total exposure) • Jason Jennings, Melbourne, Australia

>This galactic triplet resides in Virgo. NGC 5560, NGC 5566, and NGC 5569 travel through space together, their gravitational interactions distorting the spiral arms of all three objects. (24-inch RC Optical Systems Ritchey-Chrétien reflector at f/8, SBIG STL-11000 CCD camera, LRGB image with exposures of 135, 40, 40, and 40 minutes, respectively) • Adam Block, Mount Lemmon SkyCenter, University of Arizona

Van den Bergh 134 is a reflection nebula in the constellation Cygnus the Swan. It shows up in this sea of red emission nebulosity as the bluish cloud that surrounds the bright blue star below the center of this image. (Astro Systeme Austria N12 astrograph at f/3.5, SBIG STL-11000M CCD camera, HαRGB image with exposures of 345, 100, 140, and 170 minutes, respectively) • Thomas V. Davis, Inkom, Idaho

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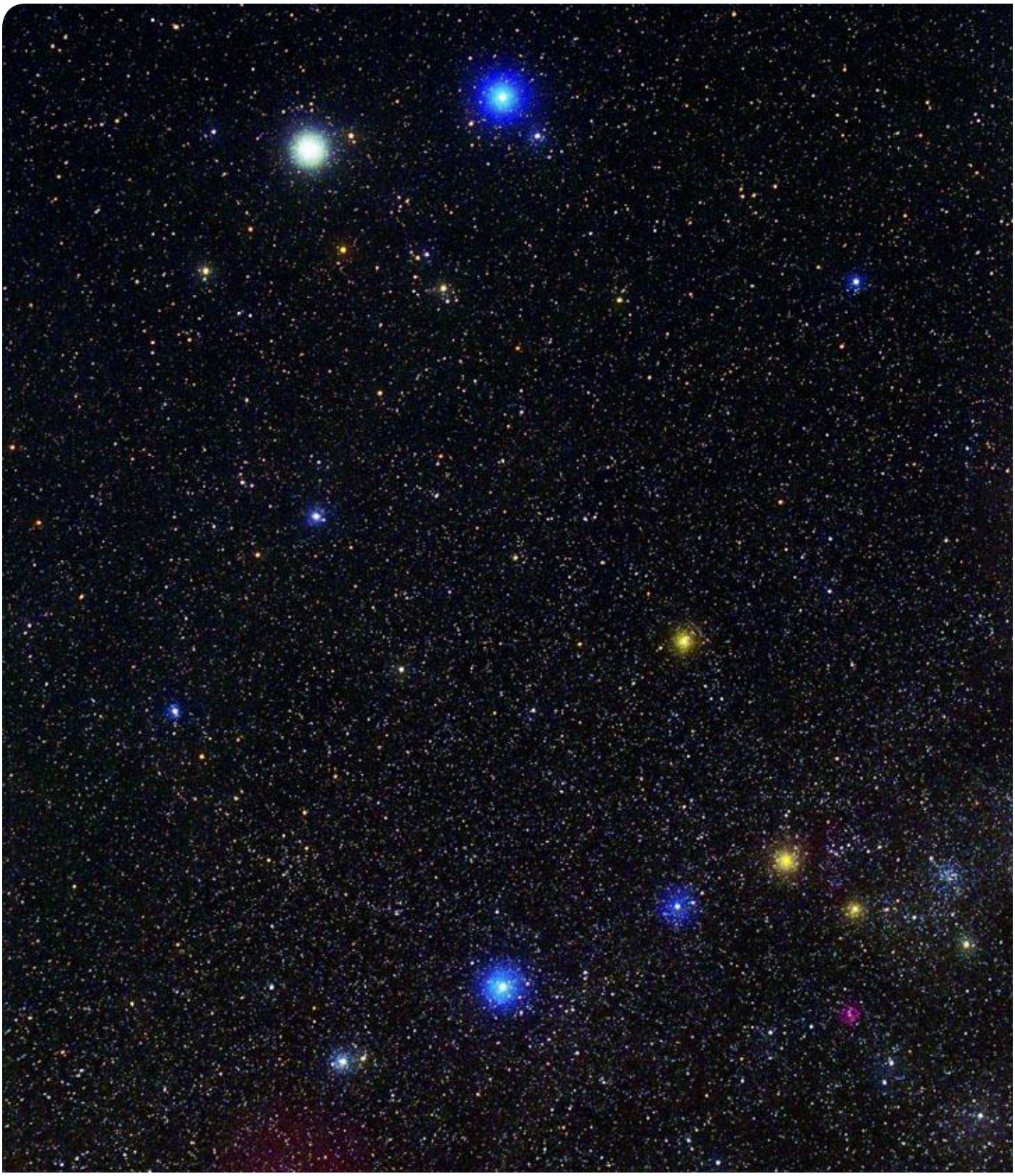

The constellation Gemini the Twins stands high in the sky during winter in the Northern Hemisphere. Blue Castor (Alpha [α] Geminorum) and Pollux (Beta [β] Geminorum) mark the heads of the brothers. Gemini's only Messier object, open cluster M35, glows at the lower right, near two orange stars. (Guided exposure with a special filter that slightly diffuses the bright star images) • Bill and Sally Fletcher, Little River, California

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Meade ups the ante with the introduction of an 8 inch LightSwitch telescope. With 78% more light gathering power than the LS-6, the LS-8 turns a unique viewing experience into an unsurpassed viewing experience. And still, it's just as easy as flipping a switch.

LightSwitch Technology

When Meade announced LightSwitch Technology in early 2009, the amateur astronomy game changed. Simply flip a switch and LightSwitch automatically aligns itself in the night sky. Built-in GPS, magnetic north sensors, level sensors and a CCD camera does all the work — within minutes your observing!

Astronomer Inside™

Let Meade's Astronomer Inside take you on a multi-media guided tour of the night sky. Choose the Tonight's Best tour and the Astronomer Inside automatically moves the telescope to the best objects in that night's sky. At each object, listen as the Astronomer Inside describes in detail, fascinating facts and history. Attach the optional video monitor and you now have a dazzling multi-media presentation that integrates rich audio and video. Or select your favorite object and your LS telescope takes you to it and tells you all about it. It's like having an astronomer at your side!

Meade Optics

Since 1972, Meade has consistently manufactured the finest optics available. Now you have your choice of either Meade's high-performance Schmidt-Cassegrain (SC) optics, or — for the truly discerning individual who demands the very best — Meade's Advanced Coma-Free™ (ACF) optical system delivering the sharpest, brightest image available. Both systems are made with superior materials featuring Schott® water white glass front correctors, oversized Pyrex® primary mirrors and include Meade's UHTC™ coatings for optimum light transmission. Either way, you get Meade's legendary optics.

Finding out more about the new LS-8 is almost as easy as using one — just go to www.meade.com.

LS-8 ACF - $1,999 • LS-8 SC - $1,799

LS-6 ACF - $1,499 • LS-6 SC - $1,399

**Optional LS 3.5" Color LCD Video Monitor $99*

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